



AN INTRODUCTION TO DELAY LINES BY COMPUTER DEVICES CORP.

LUMPED CONSTANT MAGNETOSTRICTIVE DISTRIBUTED

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With the increased popularity of radar systems, computers, and other digital devices, an ever-increasing demand for components that can give the designer time control over his pulse information has led to the popularity of various types of Delay Lines. In general Delay Lines are used wherever systems and equipments use electrical information related to time. Devices such as computers, guided missiles, radar systems of all types, identification coders and decoders, telemetering systems, navigation systems, pulse forming networks, color television all require Delay Lines to control the time position of information. They are used for such things as information storage, radar target cancellation, generation of precise timing pulses, signal compression and expansion, radar range marker generators, radar range calibration, etc.

At present, the popular type Delay Lines fall into two categories - the electromagnetic and the sonic Delay Lines. Electromagnetic Delay Lines are further designated by the type circuitry used, falling into three basic categories - the lumped constant Delay Line, the distributed constant Delay Line and the delay cable. The sonic Delay Lines fall into two categories - the magnetostrictive Delay Line and the solid ultra-sonic Delay Line (crystal type). Computer Devices Corporation, at this time, specializes in the design, development and production of lumped constant, distributed constant and magnetostrictive Delay Lines. We do not manufacture Delay Cable but occasionally on customer requirement purchase the cable, treat it, package it, terminate it and deliver a completed unit to the customer. There are no plans in the near future to deal in the solid ultra-sonic type.

Delay Lines are made to give a fixed delay; they are tapped to provide a series of delays, and are made variable to provide either switch type, decade, or continuous variation of delay time.

Because applications of Delay Lines are so varied and because of the infinity of combinations of requirements that are used, Delay Lines are usually custom designed for specific applications. Although CDC catalogues specific units, these units are seldom purchased as shown in the catalogue sheets. The customer usually wants some variation which his particular equipment requires. CDC does stock standard components and is able to custom design and produce a unit in a matter of a week or two, depending on its complexity.

A Delay Line is basically a transmission line which, through circuitry or electromechanical means, has been compressed into a small volume. Its function is to delay information for a specific length of time, usually in the microsecond range.

In the electromagnetic type Delay Lines, where delay is obtained through the use of networks consisting of inductors and capacitors, the Delay Lines are governed by transmission line theory. Transmission line theory, in turn, is derived from filter theory as the number of sections approaches infinity. Therefore, a Delay Line has many of the characteristics of both a transmission line and of a filter. The distributed line more closely approximates a transmission line, and the lumped con-

This paper provides a simple, non-technical presentation of the field of Delay Lines. Delay Lines of all currently popular types are described, simplified theories of operation are shown, applications are discussed and attainable characteristics are related to size and prices. It should be of interest to technical as well as non-technical personnel who deal in these versatile components.

Prepared for you by "Gene" Wendolkowski and "Ken" Dunne of CDC, who are always available to you for discussion of any Delay Line problems. Telephone Area Code 516 - AR 1-0666.

stant line more closely approaches a filter. A true transmission line has almost no degradation of signal frequencies up to hundreds of megacycles. As more delay is obtained for the same volume, the higher frequency response suffers. The greater the compression the lower the upper cut off frequency. In a distributed constant line, this compression is accomplished by increasing the delay per inch; in a lumped constant line by decreasing the number of sections. It is necessary to introduce phase compensation into the line to insure that all frequencies up to the cut-off are delayed equally. Insufficient delay of higher frequencies causes pre-shoot in the step response of the line. Since Delay Lines are normally used for step functions and square waves rather than sine waves, it is convenient to express the line in terms of the rise time (at the output) of a perfect step function introduced at the input. The relationship between (F) frequency response (3db Pts.) and rise time (t_r) is expressed by the equation

$$F_c = \frac{.36}{t_r}$$

LUMPED CONSTANT DELAY LINES. The lumped constant Delay Line in its simplest form consists of a number of inductors and capacitors all similar in value (see Fig. 2). The inductors are connected in series and the capacitors are connected through the junction between the inductors to the ground lead. The number of inductor capacitor sections which are required to obtain a particular frequency response or delay (t_d) to rise time (t_r) ratio is represented by the empirical equation

$$n = \left(\frac{t_d}{t_r} \right)^{3/2}$$

This equation holds fairly well for ratios (t_d/t_r) up to 50 to 1. Higher ratios than this are obtainable in certain cases but in most cases are difficult because of the difficulty in obtaining the required "Q" for the coils. At CDC, complex sections, special powdered iron cores and novel construction are used to reduce the number of sections required to a basic minimum. The price of a lumped constant Delay Line is therefore closely related to the number of sections required. The cost per section is also influenced by the size of the inductor and the capacitors needed. Equations governing the inductance and capacitance required are shown below.

$$C = t_d / Z_o \quad C = \text{Capacitance} \quad Z_o = \text{Impedance}$$

$$L = t_d \times Z_o \quad L = \text{Inductance} \quad t_d = \text{Delay Time}$$

In the usual short delay Delay Line, the inductors are worth approximately 30¢ and the capacitors around 24¢. With factors introduced for wiring the unit, encapsulating, canning, etc., the cost per section approaches \$1.00 per section in small quantities and approximately half that in large quantities. Where inductors are necessarily large, requiring the use of large toroidal coils, the coil form alone can cost \$1.00 and the finished coil \$2.50 or more. Capacitors for long Delay Lines like this sometimes run \$2.00 and it is not uncommon to require a cost of \$8.00 to \$10.00 per section when Delay Lines in the audio frequency range are specified.

A Delay Line must also be built to match the operating impedance of the circuit with which it is to be used. It is necessary, therefore, at all times, to specify impedance for impedance governs the unit value of the



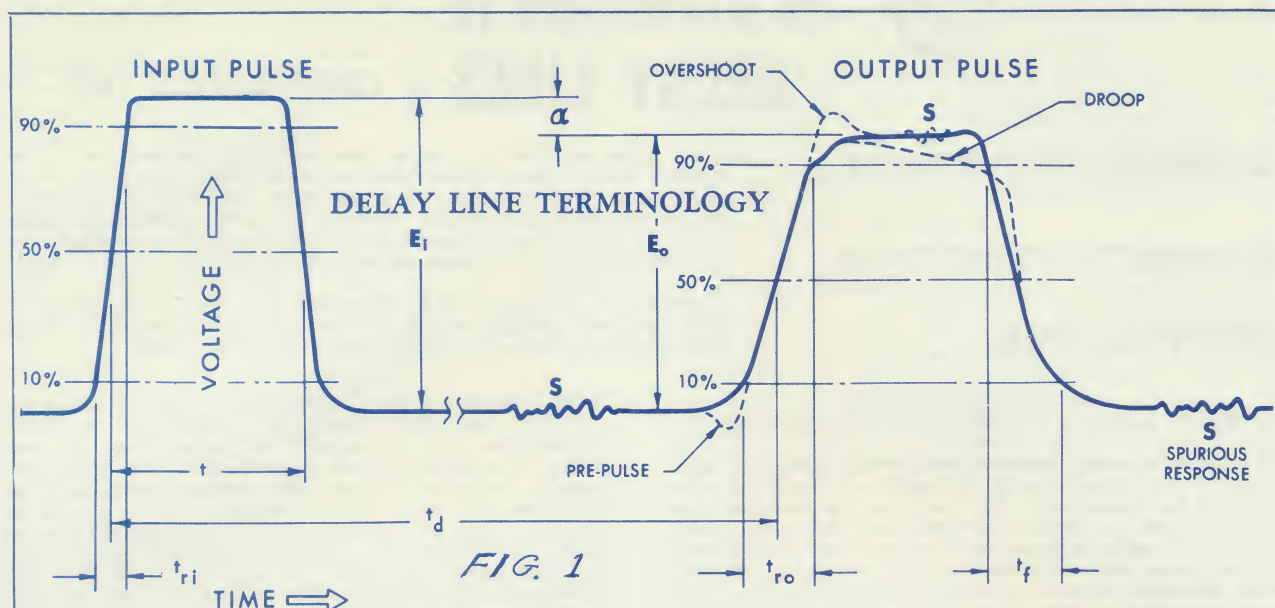


FIG. 1

- t_{ri} Input pulse rise time
- t_{ro} Output pulse rise time
- t_r Network pulse rise time = $\sqrt{(t_{ro})^2 - (t_{ri})^2}$
- Overshoot...A continuation of the leading edge of the pulse
- Droop...A sloping of the top of the pulse
- t_f Fall Time
- α Attenuation (in db) = $20 \log E_i/E_o$
- S Spurious Response - Distortion - Ripple... Three common terms used to define any irregularities in the signal output of the delay line due to various causes. This may be expressed as db below E_o
- t Pulse Width...Usually measured at 50% amplitude points.
- t_d Delay Time...The pulse delay is usually measured from the 50% amplitude point of the leading edge of the input pulse to the 50% amplitude point of the leading edge of the output pulse.

Z_o Characteristic Impedance...That value of terminating impedance which provides minimum reflection to the input of the line.

t_d/t_r Delay to Rise Time Ratio...The ratio of total delay to the delay line rise time is one measure of the quality of the delay line. (Figure of Merit)

Bandwidth...Those frequencies which are passed at a useful amplitude (attenuated 3db or less, for example). This is related to rise time approximately by

$$\text{bandwidth} \times \text{rise time} = .36$$

Temperature Coefficient...Usually expressed as a percentage change in delay per degree Centigrade or parts per million per degree Centigrade (PPM/°C).

Phase Shift...Delay lines may be used as phase shifting devices. A delay line will shift the phase of a sine wave an amount in degrees equal to $360 \times \text{delay time} \times \text{frequency of sine wave}$. $\theta = 360 \times t_d \times f$.

inductance and capacitance - therefore, the Delay Line price i.e., it is possible to reduce the impedance of a long Delay Line thus reducing the size of the inductance to a point where its price becomes nominal. Impedance also governs the ability to make certain Delay Lines, i.e., when high impedance is specified; from

equation $Z_o = \sqrt{\frac{L}{C}}$ it is seen that large inductors

and small capacitors are required; if the value of capacitance becomes too small, high response Delay Lines cannot be made due to stray capacitances influencing the proper LC balance.

Lumped constant Delay Lines can be made with very good temperature stability. Normal stabilities are about 40-50 PPM/°C and can be made as low as 5 PPM/°C. Delay accuracy also affects the price of a Delay Line. Accuracies of .05 us $\pm$ 1% are normal and accuracies of .010 us $\pm$.1% are achieved for a price.

Lumped constant Delay Lines can be tapped at several points to give a series of delays. The number of such taps and the accuracy of the tapped delay also adds to the price of the Delay Lines. Lines can be tapped to an accuracy and spacing to two times the rise time of the Delay Line for a nominal cost and to .01 $\pm$.1% for a higher price.

The amount of permissible ripple on a Delay Line can also affect the price. Ripple is a function of impedance

matching within the Delay Line, the number of sections of the line and external effects of the casing and construction on the Delay Line. Normal ripple is less than 10% of the output pulse amplitude. Ripple as little as .1% can be achieved by proper and careful construction. However, such a Delay Line would be very expensive.

Normally, CDC Delay Lines are made in very small packages consistent with the use of existing components which are available at low cost. Where extreme miniaturization is required, CDC uses sub-miniature components and is able to achieve miniature size unsurpassed by any other manufacturer. Prices of miniature units are naturally higher than normal units.

At CDC, the lumped constant Delay Lines are made to meet military specifications. Most are hermetically sealed in metal containers, they are usually resin encapsulated with a foam material. They are built to withstand the shock and vibration of military requirements.

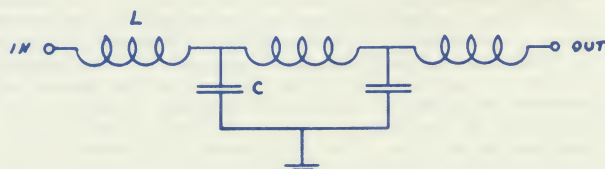


FIG. 2

Lumped constant Delay Lines having delays from .01 us to 100,000 us are made at CDC, and delay to rise time ratios up to 170 to 1, impedances from 20 to 20,000 ohms are available. The size of lumped constant Delay Line depends on the delay to rise time ratio and the total delay of the Delay Line.

DISTRIBUTED CONSTANT DELAY LINES. Distributed constant Delay Lines more closely approximate the transmission line. They are made by winding a continuous coil (usually multi layer) on a glass or ceramic rod that has been coated with a conductive material such as silver to provide a ground conductor pattern. This rod is covered with a thin layer of dielectric such as Polystyrene, Teflon, or Mylar. The coil provides a continuous inductance along the rod and the capacitance is obtained between the coil wire and the ground plane. (See Fig. 3)

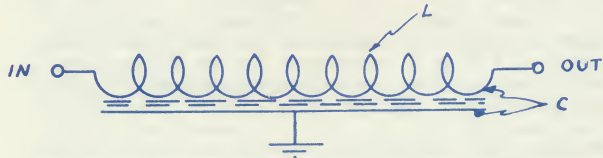


FIG. 3

Distributed constant lines are limited in their delay to rise time ratio and generally do not exceed a delay to rise time ratio of 10 to 1. They are also poor in respect to temperature, having a coefficient of delay of 150 PPM/°C normally, and 100 PPM/°C at best.

To attain a 10 to 1 delay to rise time ratio, a distributed constant Delay Line winding must be at least 6" long. Delays of up to 5 us can be achieved with one 6" winding. Longer delays in shorter windings can be attained but at the sacrifice of the delay to rise time ratio. Distributed constant Delay Lines may be cascaded to obtain longer delays. Not all impedances are possible for every delay because of the limitation of the amount of capacitance that can be attained from the area of the winding. At CDC special techniques allow us to stretch the above limits a slight amount, however, this affects the price.

The same basic equations for L and C, as shown above, apply to distributed constant lines. The C is the total capacitance between the coil and the ground plane.

Distributed constant Delay Lines are nominally priced. the usual 10:1 (t_d/t_r) stick line, housed in a 3/8" x 3/8" x 6" case, will cost approximately \$15.00 for a single unit, and \$3.00 to \$4.00 in large quantities. These units are also built to meet military specifications and are generally epoxy encapsulated.

DELAY CABLE (not manufactured by CDC.) Delay cable is basically a distributed constant Delay Line but with a much longer winding. Consequently, delay per inch is very small. Delay cables, depending on the method of manufacture provide very good frequency response but have the same shortcoming as distributed lines as far as temperature is concerned. They also have very high attenuation of signal associated with them. As stated above, on customer request, CDC packages and trims delay cable, when requested.

MAGNETOSTRICTIVE DELAY LINES. Magnetostrictive Delay Lines, in effect, reduce the velocity of an electrical wave by converting it into a sound wave and then reconvert it back into its electrical form. The simplest magnetostrictive line (figure 4) consists of an



FIG. 4

input transducer coil with a magnetostrictive core attached to a wire sonic waveguide. The far end of the sonic waveguide is attached to a similar output transducer. The magnetostrictive effect refers to the fact that if a magnetic field is applied to a sample of magnetostrictive material, parallel to its length, it will undergo

a change in length. The inverse magnetostrictive effect refers to the fact that if the sample is subjected to a mechanical strain while biased in a magnetic field there will be a change of flux in the sample. At the input transducer, flux change in a coil creates a mechanical stress in the magnetostrictive core which travels down the waveguide wire as a sound wave. When the wave reaches the output transducer, it alters the permeability of the magnetostrictive core which is polarized by the permanent magnet. The resulting flux change induces an electrical signal in the output coil. Acoustic absorbers at each end of the magnetostrictive line prevent signal wave reflections.

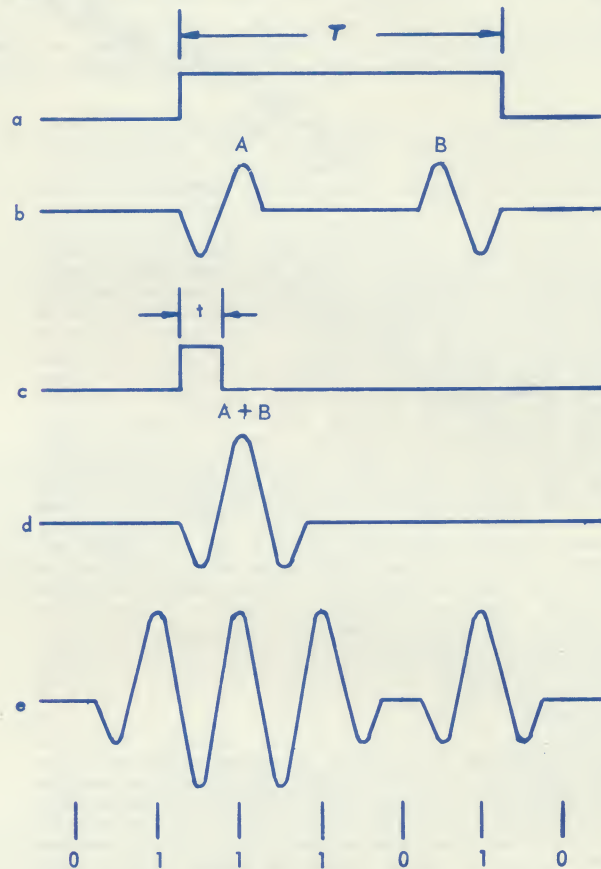


FIG. 5

Output wave forms are determined by the duration of the input pulse. In figure 5a the input pulse duration t is appreciably longer than the time taken for a strain pulse to travel the line one transducer coil length. This produces an output voltage as shown in figure 5b. In figure 5c, the duration of the input pulse is less than or equal to t . This produces an output pulse, as shown in figure 5d. This output is formed by the positive portions A & B of figure 5b forming a single positive peak. It is this coalesced positive peak which is used in systems operating in a digital fashion. Input pulse width t can be adjusted to an optimum for the Delay Line and the given pulse spacing. When the Delay Line is adjusted for the optimum digital rate, a typical random pulse output pattern for a code of 0-1-1-1-0-1-0 is shown in figure 5e.

The magnetostrictive Delay Line shown in figure 4 makes use of longitudinal sound waves, i.e. waves in which particle motion is in the same direction as wave motion. It is useful in low to medium delay bandwidth applications and can be readily tapped. To make a longer Delay Line, the wire waveguide must be coiled to fit a reasonable space. However, when this is done the signal is distorted considerably. The arrangement shown in figure 6 provides maximum delay without distortion — consequently higher bandwidth. It consists of the usual sonic waveguide and transducer. This time the transducers are joined to the waveguide at right angles and are connected so that they provide and respond to a torsional wave in the wire. The torsional waves travel with negligible dis-

tortion down the waveguide wire. Torsional waves also travel slower down a waveguide; whereas in the longitudinal mode the delay per inch of waveguide wire is approximately 5 usec, in the torsional mode the delay per inch is 9 usec.

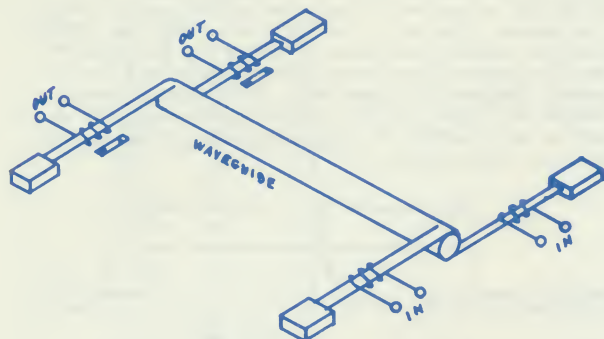


FIG 6

Magnetostrictive Delay Lines are extremely useful where pulse information or trigger information requiring long delays is involved. They are not generally used in applications where the shape of the pulse has to be preserved. Due to the fact that they are converting energy from electrical to mechanical and back to electrical, considerable attenuation of the signal is experienced. An insertion loss of -50 to -70 db can be expected. Magnetostrictive Delay Lines provide very long delays in very small space, and digital operating frequencies up to 5 megacycles. They are capable of having their total delay and tapped delays adjustable; they are extremely stable with temperature. CDC manufactures magnetostrictive lines with delays up to 20,000 us, however, delays of over 10 milliseconds are difficult to obtain but can be done for a price. Normal maximum frequency response or digital bit rate is 1 megacycle for delays up to 7 milliseconds. Frequency responses higher than 2 megacycle are still somewhat of a laboratory novelty except for short delays (20 to 30 us) which can be produced with frequency responses of up to 5 megacycles.

The temperature stability of a magnetostrictive Delay Line depends on the stability of the wire waveguide material. With normal materials, stabilities of better than 5PPM/°C are attainable; with special care and special heat treat, stabilities of better than ½PPM/°C are feasible. Normal signal to noise ratios run about 10 to 1 but 20-30 to 1 can be provided. Impedances of input and output transducers from 50 to 3,000 ohms are available.

Short delay longitudinal lines are generally packaged in long, slim packages. A normal package would be 3/8" x 1" in cross section with length dependent on the delay required. A 20 us Delay Line will be 7" long. Greater delays will increase the length by 1" for every additional 5 us. Long delay torsional Delay Lines are housed in flat, square packages. A normal package for delays up to 3,000 us would be 6½" x 7½" x ½". All fixed Delay Lines are provided with a small delay adjustment, usually a swing of 3 us. Pricing depends on frequency response, temperature stability and signal to noise requirements. Longitudinal lines are sold for approximately \$100 in single quantities and down to \$20 to \$30 in large quantities. Torsional lines between \$150 and \$300 for single quantities and are priced as low as \$50 to \$80 in quantity. Most magnetostrictive Delay Lines are made to meet military requirements and are housed in hermetically sealed metal containers. They are built to withstand shock and vibration as required.

SOLID ULTRA-SONIC DELAY LINES. (Not manufactured by CDC.) Solid ultra-sonic Delay Lines operate basically on the same principle as magnetostrictive Delay Lines. Here usually a block of fused quartz is used as the delay medium. Piezoelectric transducers are cemented to the quartz at the input and output extremities of a pre-determined delay path. An electrical signal applied at the input transducer creates a mechanical vibration. This vibration is propagated along the delay path until it reaches the output transducer. At

this point the vibration is transformed again into an electrical signal. Information carried by this signal is delayed in time by an amount dependent on the length and nature of the delay medium. Spacesaving is accomplished in this type of Delay Line by the use of a folded path where the beam is reflected off the sides of the quartz blank, in this manner allowing longer delays in smaller blank size. Solid ultra-sonic Delay Lines are capable of operations at much higher frequencies than magnetostrictive lines. However, their temperature coefficient is quite poor (-70 PPM/°C). They are not as rugged and are much bulkier.

VARIABLE DELAY LINES. CDC makes variable Delay Lines using the three types that we manufacture. Where high delay to rise time ratios are required, lumped constant Delay Lines are used and are tapped with the taps being attached to an appropriate switch. A standard rotary variable Delay Line configuration is shown in our catalogue sheet (V108, 150 etc.) wherein a 60 position shorting type commutator switch is used, thus providing a 120 to 1 resolution for the Delay Lines. Variable Delay Lines with decade type switching are also constructed.

There are also applications wherein a tapped Delay Line cannot be used — because the impedance at the tap must be at least 10 x the impedance of the line. For cases like this, CDC manufactures an insertion type variable Delay Line. Here each delay setting is a complete Delay Line so that external load can be at the impedance of the Delay Line as opposed to a tapped line where the load impedance must be very much higher than the characteristic impedance of the Delay Line to avoid undesirable reflections.

Where higher resolution is required, lumped constant Delay Lines are built, using a continuous solenoid coil with a wiper arm wiping along the coil, thereby providing a tap with a resolution equivalent to the total number of turns of the coils in the entire Delay Line. These lines are usually packaged in long narrow containers and use a lead screw delay adjustment shaft (V176 & V172).

Distributed constant variable Delay Lines are made in a manner similar to the high resolution lumped constant Delay Line, except that the capacitance is again attained in the same manner as described for the distributed constant line above. However, distributed constant variables suffer from the same limitations in temperature coefficient and limited (t_d/t_r) as distributed lines as previously mentioned.

Magnetostrictive Delay Lines are made variable simply by making either the input or output transducer mechanically movable. However, all variable magnetostrictive lines must be made using the longitudinal mode.

Short delay variables are made using a lead screw type adjustment and have a configuration similar to the distributed constant variables described above. Long delays are attained in much the same manner as multi turn potentiometers wherein the delay wire is wound into a helical form and the transducer is moved over the entire wire length in several turns of the control shaft. All ranges from 5 to 5000 usec are made. Because these lines use the longitudinal mode, lines with delays over 100 usec are subject to periodic pulse phase reversal; consequently, special output circuitry to eliminate this effect is necessary. Overall accuracy of line and circuitry is better than 0.2%. Variable magnetostrictive lines are finding wide application in range and delay calibration devices because they are compact, passive and capable of high reliability.

As the field of Delay Lines grows and requirements become more stringent, and more demanding, the ingenuity of the Delay Line designer plays an important part and should be utilized by the customer when designing new equipments. Many new developments are currently being undertaken at CDC and as their feasibility is proven, bulletins will be issued and sent to the recipients of this paper.

**LONG DELAYS
OF COMPLEX
0 TO 400 KC
CW SIGNALS**

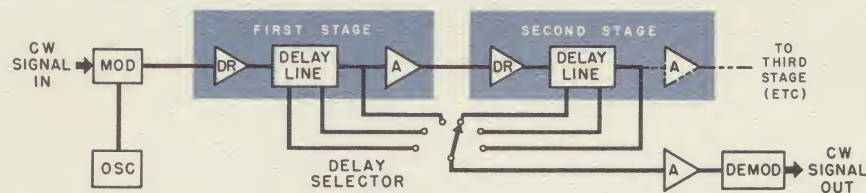
COMPUTER DEVICES

MODULATED CARRIER MAGNETOSTRICTIVE DELAY LINE SYSTEMS

DELAY CONCEPT

Magnetostrictive Delay Lines which are normally used for pulse and digital applications also provide an excellent means for obtaining extremely long delays of complex continuous wave signals by driving the Delay Lines with a carrier frequency and AM or FM modulating the carrier.

C. W. signals with frequency contents from zero up to 400 Kcs are faithfully preserved over very long delays with maximum delay dictated by economics alone. These units are usually supplied as a complete unity gain system which includes the magnetostrictive Delay Line, the line amplifiers and drivers, the carrier frequency oscillator and the modulator and demodulation circuitry; or, if it is preferred, suitable Delay Lines can be provided with recommendations for matching circuitry. A typical system schematic is shown below.



TOTAL DELAY AND TAP DELAYS

Extremely long delay can be provided by cascading stages as shown with no theoretical limit on maximum delay. The delay per stage depends on the carrier frequency used and whether or not the Delay Line must be tapped for intermediate delays. Untapped lines will have a per stage maximum delay of 15 milliseconds with a 500 Kc carrier and 5 milliseconds with a 1 Mc carrier. Carrier frequencies of up to 2 Mc are possible.

CDC's novel method of obtaining tap delays allows as many delay tap points as desired without any deteriorating effects to the signal. In the case of tapped Delay lines, the maximum delay per stage is 6 milliseconds.

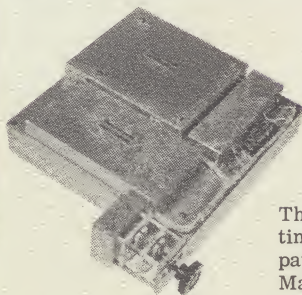
TEMPERATURE STABILITY

These systems are made extremely stable with temperature and are normally 10 PPM/°C. When required, stabilities of better than 1 PPM/°C can be specified.

PERFORMANCE

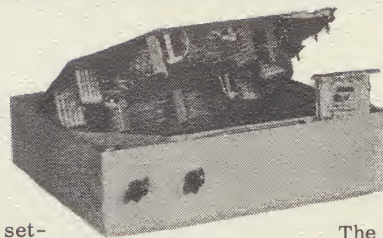
All the characteristics of the input signal are maintained at the delayed output with little or no phase distortion and low VSWR. Dynamic range is better than 20 db.

TYPICAL SYSTEMS



MS 574

The MS574 provides 24 delay settings spaced in an irregular delay pattern to an accuracy of $\pm 1\%$. Maximum delay settings is 10 milliseconds. The unit operates with a 1 Mc carrier which is modulated by a complex FM/AM modulation with a deviation of ± 250 Kc. Size is 12 x 12 x 3".



MS 400
(SHOWN PARTIALLY
DISASSEMBLED)

The MS400 is a unity gain delay system which provides 7 delays to a 70 Kc carrier which is modulated with a 5 to 5000 cycle C.W. signal. Delay is switch selected, giving a choice of delay settings from 100 to 6000 microseconds in a single stage Delay Line. Delay accuracy of ± 1 usec is maintained over a temperature range of 20 to 120°F. Size is 13 x 13 x 4".

TECHNICAL ASSISTANCE

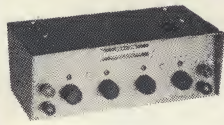
CDC engineers are always available to assist you in determining the most economical specifications to meet your Delay Line requirements. A telephone call often saves many hours of research.

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DELAY LINES ELECTROMAGNETIC FIXED - TAPPED - VARIABLE

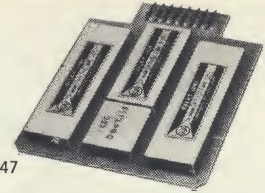
TO
MILITARY
AND
COMMERCIAL
SPECIFICATIONS



V492



DV576A



V447-D647

FIXED AND TAPPED DELAYS		Model	Delay microsec.	Rise Time Kc	Step or Tap Delay μ sec.	Impedance Ohms	Attenua- tion db	Size
CODING LINES for Radar Recognition Sets — Tap spacing 1.45 μ sec. Accuracy up to ± 0.02 μ sec over Mil. specs. Lumped Constant hermetically sealed units — other tap spacings available.		D110	24.65	.45	1.45	180	6	8 x 4 x 2.5
		D180	25.3	.55	1.45	2200	3	4.37 x 3.25 x 2.12
		D203	20.3	.35	1.45	470	3	10 x 2.5 x 2.25
		D170	20.3	.60	1.45	510	3	4 x 2 x 1
		D231	20.3	.50	1.45	2200	2	4 x 3 x 2
		D735	20.3	.50	1.45	500	4	4 x 4 x .5
Slab type for printed circuit mounting.		D286	.5	.05		1000	1	3.5 x .5 x .5
		D148	10.0	.3		1000	3	2.12 x 2.12 x 4
		D121	15.0	.25		1000	2	2.25 x 3.75 x 4.25
		D754	50	1.5	.5	1000	6	4 x 4 x 2
		D414	100	3.0	1.0	500	4	6 x 3.5 x 3
		D136	200.0	6.0		1000	6	2.12 x 2.12 x 4
TYPICAL LUMPED CONSTANT TYPES — Large variety of performance characteristics available. Delay to rise time ratios of up to 175 to 1 — accuracies up to .1% over Mil. Spec. range. Hermetically sealed in metal containers.								
AUDIO DELAY AND SONAR LAG LINES		Model	Delay microsec.	3 db B.W. Kc	Step or Tap Delay μ sec.	Impedance Ohms	Attenua- tion db	Size
FIXED AND TAPPED DELAYS of low frequency C.W. signals. High accuracy of delay — Temperature stability 40 PPM/ $^{\circ}$ C, VSWR $\pm 1/2$ db. Phase linearity $\pm 1/4$ %.		DA563	500	30	25	1000	6	7 x 2.5 x 2
		DA301	1000	20	20	600	3	19 x 3.5 x 9
		DA261	5000	5	40	500	3	19 x 5.25 x 10
		DA607	20000	3.5	80	500	1	19 x 7 x 15
		DA177	100000	.2	1000	1000	10	19 x 21 x 12
VARIABLE DELAYS — Decade insertion type switching — provides low signal distortion and input and output impedance of equal value — Other characteristics same as fixed line.		AV175	0 - 150	30	.1	500	6	9 x 3 x 6
		AV287	0 - 500	20	.002	1000	3	19 x 3.5 x 12
		AV206	0 - 1000	20	1.0	600	3	19 x 3.5 x 12
		AV731	0 - 5000	5	.1	1000	2	19 x 5.25 x 15
		AV211	0 - 10000	2.5	.1	600	3	19 x 5.25 x 15
VARIABLE DELAYS		Model	Delay Range microsec.	Rise Time microsec.	Resolution	Impedance Ohms	Attenua- tion db	Size
One Turn	Movable tap on coil type.	DV252	0 - .06	.02	1/300	330	.5	1.5 dia. x .75
	60 position switch type.	V168	0 - .2	.15	1/120	100	.5	4 x 4 x 1.25
Multi-Turn	Movable tap on coil type.	DV186	0 - .5	.06	1/1000	500	1	.62 x 1.25 x 6.5
	Movable tap on coil type.	V172	0 - .55	.08	1/1000	1000	1	.5 x 1.5 x 4.5
Multi-Turn	35 pos. longitudinal switch type.	V703	0 - .95	.07	1/70	500	1	.75 x 1.87 x 7
	Movable tap on coil type.	V289	0 - 1.0	.2	1/1000	500	1	.5 x 1.5 x 4.5
Multi-Turn	Movable tap on coil type.	DV219	0 - 1.0	.11	1/1000	1000	1	.62 x 1.25 x 6.5
	30 pos. longitudinal switch type.	V443	0 - 3.0	.25	1/60	200	2	.62 x 2 x 4.5
Multi-Turn	Movable tap on coil type.	V176	0 - 3	.5	1/1000	330	2	.75 x 1.87 x 7
	Phase Shifter for up to 200 Kc.	V649	0 - 10	1.8	1/2000	100	4	2 x 2 x 8
INFINITE RESOLUTION — Inductive pick-off — Distributed Constant.		VP162	0 - 7	.3	Infinite	150	30	2 x .75 x 5
		VP333	0 - 12	1.2	Infinite	10000	30	1.37 dia. x 10
INSTRUMENT TYPE. Decade switch variables — Direct in-line numerical display of delay setting — For Lab and equipment use.		V492-1	0 - 20	.5	.01	1000	5	8 x 5 x 3
		V492-2	0 - 30	.7	.01	1000	6	8 x 5 x 3
		V492-3	0 - 10	.3	.01	1000	3	8 x 5 x 3
		V492-4	0 - 100	3.0	.01	1000	3	8 x 5 x 3
ULTRA MINIATURE VARIABLES		Model	Delay Range Nanosec.	Rise Time Nanosec.	Resolution Nanosec.	Impedance Ohms	Attenua- tion db	Size
NANOSECOND RANGE COMPUTER TRIM-DELAYS. Hermetically sealed in metal cases — "O" ring seal on control shaft — for printed circuit board mounting. Can be cascaded with Series D647.		V447-1	0 - 55	15	.5	150	1	1 x .31 x 1.25
		V447-2	0 - 100	30	.7	50	1	1 x .31 x 1.25
		V447-3	0 - 150	25	.6	150	1	1 x .31 x 2.45
		V447-4	0 - 250	30	1.0	50	1.5	1 x .31 x 2.45
		V447-5	0 - 300	30	.6	150	1.5	1 x .31 x 3.45
		V447-6	0 - 500	60	1.0	50	2	1 x .31 x 3.45
D647 SERIES — MINIATURE MODULES		Delay Choice		Choice Impedance	Delay to Rise Time Ratio	Size		
Lumped Constant Printed circuit mounting modules can be cascaded to obtain any desired delay. Case size depends on delay to rise time required. Units are compatible with variable V447 series. *Tapped each 1.45 μ sec. for use in coders.		50; 100; 250; 500 and 750 nanosec.		50 ohms	4:1	1 x .31 x 1.25		
		1.0; 1.45; 2.90* and 4.35* microsec.		150 ohms and 500 ohms	8:1 12:1	1 x .31 x 2.20 1 x .31 x 3.45		
DO IT YOURSELF DELAY ADJUSTMENT		Part No.		Section Delay — Nanosec.		Tot. Delay Nanosec.	Rise Time Nanosec.	
5 completely separate sections in each module. Cascaded modules allow selection of any desired delay in 5 nanosec. increments. Ideal for experimental work. Size of all modules 1 x .31 x 2.25 for printed circuit mounting.		Imp. 93	Imp. 330					
		D740	D741	5; 10; 20; 30; 40		105	15	
		D742	D743	50; 100; 200; 300; 400		1050	150	
		D744	D745	One Delay		100	15	
		D746	D747	One Delay		1000	150	
ELECTRICALLY VARIABLE		Model	Delay μ sec.	Rise Time μ sec.	Distortion %	Impedance Ohms	Attenua- tion db	Size
Delay is varied by varying a D.C. control voltage. Both L & C are controlled to minimize mismatch.		DEV623A	.03 to .04	.008	10	150	2	2 x 1 x .31
		DEV350	3 to 7	.25	10	1000	3	3.5 x 4 x 4

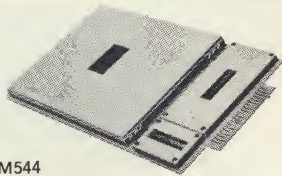


COMPUTER DEVICES CORP.

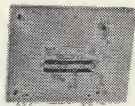
6 W. 18TH STREET, HUNTINGTON STA., L.I., N.Y.

TEL: 516 - AR1-0666, TWX: 516 - 421-4235

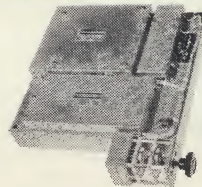
DELAY LINES MAGNETOSTRICTIVE FIXED - TAPPED - VARIABLE



DM544



MS744



MS574

**HIGH
QUALITY
FAST
DELIVERY**

FIXED DELAYS

LONGITUDINAL MODE — Short delays with $\pm 4 \mu\text{sec}$ trim adjustment; standard temperature coefficient 150 PPM/ $^{\circ}\text{C}$, provided as low as 2 PPM/ $^{\circ}\text{C}$.

TORSIONAL MODE — Ultra stable with temperature coefficient less than .5 PPM/ $^{\circ}\text{C}$ available. Signal to spurious noise 10:1 dynamic 30:1 static. All units provide a $\pm 4 \mu\text{sec}$ adjustment. Unsealed or hermetically sealed to meet MIL specs. Package thickness can be reduced by accepting next higher case width and depth.

Model	Maximum Delay Microsec.	Max. Bit Rate RZ or C.W. Cent. Freq Mc	Size
ML755	20	3.0	1 x 6 x .375
ML756	50	1.5	2 x 8 x .375
ML757	100	1.5	2 x 14 x .375
MT760	250	2.0	6 x 7 x .75
MT761	500	1.5	3 x 4 x .75
MT762	1800	1.5	4 x 5 x .75
MT763	3000	1.2	6 x 7 x .75
MT764	6000	1.0	8 x 9 x .75
MT765	10000	1.0	10 x 11 x .75
MT766	15000	0.7	12 x 13 x .75

SERIAL COMPUTER MEMORIES

COMPLETE UNITY GAIN MEMORY SYSTEMS supplied with transistorized circuitry for operation in any required mode RZ, NRZ or Bi-Polar. These units use the MT760 Delay Line series and have the exceptional stability and high signal to noise ratio of these Delay Lines. Can be cascaded and complete memory stacks are also provided.

Model	Max. Storage Bits RZ	Max. Storage Bits NRZ	Size
MS770	500	1000	8.5 x 7 x .75
MS771	750	1500	5.5 x 4 x .75
MS772	2700	5400	6.5 x 5 x .75
MS773	3600	7200	8.5 x 7 x .75
MS774	6000	12000	10.5 x 9 x .75
MS775	10000	20000	12.5 x 11 x .75
MS776	10000	20000	14.5 x 13 x .75

VARIABLE DELAYS

SINGLE SHAFT CONTROL provides infinite resolution over a wide range of delays. Ideal for Radar Range Calibration, Simulation or Correlation work.
6 decade switch system provides .1 μsec resolution.

Model	Delay Range Microsec.	Bit Rate MC	C.W. B.W. MC	Size
MV781	2 - 30	1.0	.8 - 1.2	1 x 9 x .5
MV782	30 - 100	1.0	.8 - 1.2	2 x 15 x .5
MV783	10 - 2000	0.5	.3 - .7	10.0 dia x 4
MV784	10 - 5000	0.3	.2 - .4	10.0 dia x 8
MV785	10 - 100000	1.0	.8 - 1.2	19 x 17 x 10.5

COMPLEX C.W. SIGNAL DELAYS

LONG DELAYS of low frequency. Delay of complex continuous wave signals provided by driving the Delay Lines with an H.F. carrier and AM or FM modulating it with the signal.

Model	Delay Millisec.	Step Delay Millisec.	C.W. Bandwidth Kc	Size
MS400	7.0	1.0	0 - 10	13 x 13 x 4
MS574	10.0	.4	0 - 200	12 x 12 x 3
MS786	50.0	1.0	0 - 70	19 x 17 x 8.70
MS787	100.0	.1	0 - 200	19 x 17 x 12.50

MULTIPLE OUTPUT DELAYS

CODE GENERATORS — Provide as many tap positions as desired at any spacing desired (.2 μsec min.). Fast rise times. Also provided with in and out circuitry.

MULTIPLE OUTPUTS — Adjustable independently over range $\pm 6 \mu\text{sec}$ for radar correlation work.

Model	Tot. Delay Microsec.	Number of Taps	Tap Spacing or Location Microsec.	Size
ML790	16	16	1.0	1.75 x 8 x .50
ML718	15	12	1.25	1.75 x 8 x .50
ML791	20.3	14	1.45	1.75 x 8 x .50
ML792	35,000	500	70	19 x 17 x 8.75
MS283	30.50	4	12, 15, 18, 30	4 x 12 x 1.5
MS402	48.00	6	2, 5, 8, 12, 14, 48	5 x 10 x 2.75
MS399	16.35	3	6, 12, 16	4 x 12 x 1.5

MS795 SERIES — Long Delay in the V.H.F. Range. For C.W. applications in communications work. Complete unity gain systems. Size depends on delay.

Choice of Delays	Choice of Center Frequency	Bandwidth	Size
2 microsec. to 10 milliseconds	5 Mc to 400 Mc	400 Kc	2 x MS770 Series

DISTRIBUTED CONSTANT DELAY LINES

D680 SERIES NANOSECOND MODULES

DISTRIBUTED CONSTANT — Epoxy encapsulated Temperature coefficient less than 120 PPM/ $^{\circ}\text{C}$. Case size depends on delay to rise time ratio.

Delay Choice Nanosec.	Impedance Choice Ohms	Delay to Rise Time Ratio	Size
5, 10, 20, 30	93, 330	5:1	.5 x .31 x 2.25
40, 50, 60, 70	500, 1000	10:1	1.0 x .31 x 2.25
80, 90, 100			

D679 SERIES MICROSECOND MODULES

DISTRIBUTED CONSTANT — Epoxy encapsulated Temperature coefficient less than 120 PPM/ $^{\circ}\text{C}$ — Can be cascaded to obtain longer delays — other delays and impedance available.

Delay Choice Microsec.	Impedance Choice Ohms	Delay to Rise Time Ratio	Size
.1, .2, .3, .4, .5, .6, .7, .8, .9, 1.0	330, 500, 1000	5:1, 10:1	.5 x .375 x 4.5, 1.0 x .375 x 4.5
2.0; 4.0; 5.0; 10.0	500, 1000	10:1	1.0 x .5 x 4.5

INFINITE RESOLUTION VARIABLE REEL DELAY LINE

DISTRIBUTED CONSTANT — With input and output impedance of equal value — can be spliced directly into interconnecting coaxial cables — IDEAL PHASE SHIFTER. Usable to 200 Mc — Single shaft control — BNC connectors.

Model	Delay Range Nanosec.	3 db B.W. Mc	Resolution	Impedance Ohms	Attenuation Db	Size
DV581	2 - 50	70	Infinite	200	1	1.0 x 1.75 x 5.37
DV576A	2 - 50	70	Infinite	93	1	1.0 x 1.75 x 5.37

DELAYS UP TO 100 NANOSEC. AND OTHER IMPEDANCES ALSO AVAILABLE.

This condensed catalogue information is only meant to serve as a guide. Before finalizing on a design it is most prudent to utilize the experience, ingenuity and up-to-date information of our Engineering Staff. Expert guidance, which can save you hours of searching, is as close to you as your telephone —

Telephone:
516 AR 1-0666
TWX:
516-421-4235
or call nearest Sales Rep.

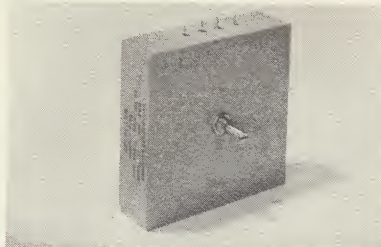


nick putatch Tel. 898-5666
Thomas M. Garrettson Co.
111 WEST AVE. SO. NORWALK, CONN.



VARIABLE DELAY LINES

STANDARD SWITCH VARIABLES



MODEL	DELAY in μ secs	RISE TIME in μ secs	Z_0 in OHMS	ATT in db	SIZE
V 108	0-3.0	.25	2700	0.8	6 x 6 x 1.5
V 125	2-5	.40	1000	1.5	6 x 6 x 1.5
V 142	0-12	.80	500	3.0	6 x 6 x 1.5
V 150	0-.5	.035	560	0.5	4 x 4 x 1.25
V 159	0-1.2	.15	2500	1.0	4 x 4 x 1.25
V 165	0-.3	.025	100	0.5	4 x 4 x 1.25
V 168	0-.2	.015	100	0.5	4 x 4 x 1.25

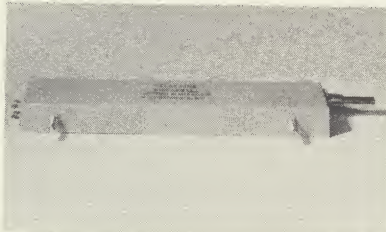
This variable delay line series is constructed using a 60 position printed circuit, rodium plated, commutator type switch. Resolution of 1/120 is obtained by a shorting feature providing an intermediate delay of approximately 1/2 step. These units are suitable for motor driven operation and have been tested for over 1/4 million cycles without any deterioration. Package size depends upon de-

lay range, impedance, and rise time. Three standard cases are available:

6 x 6 x 1.5, 5 x 5 x 1.5, and 4 x 4 x 1.25

The delay rise time ratio is better than 15:1 in most cases. Shaft locks for the 1/4" control shaft, mechanical stops, detents, and special mounting are also supplied on request.

CONTINUOUSLY VARIABLE



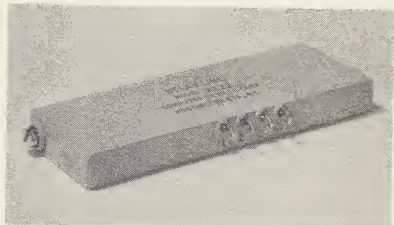
MODEL	DELAY in μ secs	RISE TIME in μ secs	Z_0 in OHMS	ATT in db	CASE SIZE
DV 186	0-.5	.06	500	1	.62 x 1.25 x 6.5
DV 190	0-.7	.09	500	1	.62 x 1.25 x 6.5
DV 219	0-1.0	.11	1000	1	.62 x 1.25 x 6.5
V 176	0-3.0	.5	330	2	.75 x 1.87 x 7
V 250	0-10	1.5	50	5	.75 x 1.87 x 7
V 251	0-15	3.0	50	8	.75 x 1.87 x 7

Featuring small control area, these variable delay lines are ideally suited for trim application where numerous lines need to be closely packaged. Delay is controlled by a lead screw providing full delay in 6 to 8 turns of a 1/4" control shaft. Variation from 0 delay to any delay specified up to 15 micro seconds, with resolution of one

part in 1000, is available.

Lines are also provided with fixed delays added to the variable sections with little or no increase in case size. Special lines with multiple tap arms are also manufactured.

MINIATURE CONTINUOUSLY VARIABLE



MODEL	DELAY in μ secs	RISE TIME in μ secs	Z_0 in OHMS	ATT in db	TEMPERATURE COEFFICIENT
V 172	0-.55	.08	1000	1	50 PPM/C°
DV 270	0-.55	.10	1000	1	200 PPM/C°
V 289	0-1.0	.20	500	1	50 PPM/C°
V 300	0-2.5	.50	180	3	50 PPM/C°
V 319	0-1.5	.30	330	2	50 PPM/C°
DV 290	0-1.0	.30	1000	2	200 PPM/C°

This series is specifically designed for printed circuit application. The miniaturized variable line has all the ruggedized construction features and reliability of other CDC variables. Both lumped and distributed constant lines are offered in this 1/2 x 1 1/2 x 4 1/2 size. A 1/4"

control shaft is located on the 1/2 x 1 1/2 surface. The lumped constant type has excellent temperature stability - .5% delay change from -20°C to +80°C while the more economical distributed constant changes 1.5% to 2% over the same range.

All CDC Variable Delay Lines are hermetically sealed in metal cans. A Special "O" ring seal is used on the drive shaft. These delay lines are manufactured to meet all the rugged environmental requirements of military specifications.

Only a few of the available models are listed above to serve as a guide. Lines to your specific characteristics will be packaged in the above case sizes.

CDC welcomes the opportunity to serve you - to assist in specifying and solving your delay line problems. We offer prompt response to your inquiries -- rapid delivery of samples and quality assured production units.

COMPUTER DEVICES CORP.

TEL: AR 1-0666

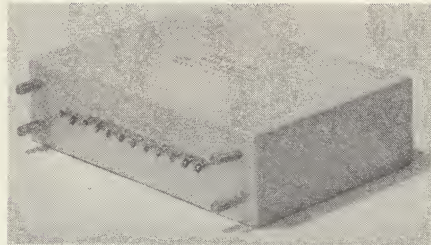
6 WEST 18 STREET HUNTINGTON STATION, N.Y.





LUMPED CONSTANT DELAY LINES

CODING DELAY LINES

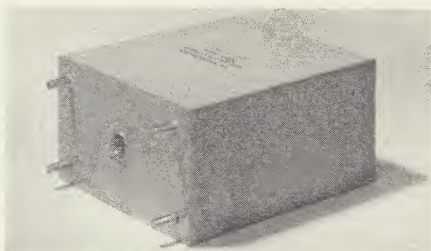


Coding Lines, primarily designed for use in transponders for aircraft identification, are compact, ruggedized, multi-tapped lumped constant delay lines. Although the number and spacing of taps can be modified to meet the requirements of any system, the usual spacing is 1.45 μ secs held to a tolerance of $\pm .05 \mu$ s at 25°C, with an additional $\pm .05 \mu$ s over the temperature range -55°C to +85°C (maximum temperature 130°C). For the more critical requirement, the tolerance can be reduced to approximate-

MODEL	DELAY in μ secs	RISE TIME in μ secs	IMPEDANCE in ohms	ATT in db	CASE SIZE
D110	24.65	.45	180	6	8 x 4 x 2-1/2
D220	25.3	.70	470	3	4 x 4-1/2 x 1-1/4
D180	25.3	.55	2200	3	4-3/8 x 3-1/4 x 2-1/8
D203	20.3	.35	470	3	10 x 2-1/2 x 2-1/4
D170	20.3	.60	510	3	4 x 2 x 1
D231	20.3	.50	2200	2	4 x 3 x 2

ly $\pm .03 \mu$ s at room temperature. These delay lines are supplied with delay to rise time ratios of up to 100, and with impedances from 50 to 5000 ohms. The attenuation for air core lines is usually around 6 db, while for iron core approximately 3 db. The attenuation, rise time and delay characteristics are normally measured with a pulse input width of between .5 and 1.0 μ s. The lines are capable of operating with any pulse voltage up to 100 volts.

STANDARD DELAY LINES

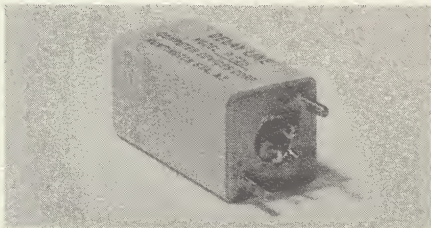


Lumped Constant Delay Lines with delays from 25 nanoseconds to .1 seconds, impedances from 25 to 20,000 ohms and delay to rise time ratios up to 100 are manufactured as standard items by CDC. The following characteristics are for all standard lines: delay tolerances $\pm 3\%$, $\pm .01 \mu$ s, impedance $\pm 10\%$, temperature stability 50 PPM/°C, distortion 10%, attenuation less than .15 x delay to rise time and operating temperature range -55°C to 125°C. These characteristics are indicative of those met at nom-

MODEL	DELAY in μ secs	RISE TIME in μ secs	IMPEDANCE in ohms	ATT in db	CASE SIZE
D260	.05	125 mc	50	.5	4 x 4 x 1
D101	.20	.016	100	1	2 x 2 x 1/2
D121	15.0	.25	1000	2	2-1/4 x 3-3/4 x 4-1/4
D136	200.0	6.0	10000	6	2-1/2 x 3 x 3
D148	10.0	.3	1000	3	2-1/8 x 2-1/8 x 4
D167	1.0	.2	50	2	1-5/16 x 1-5/16 x 3
D214	1000.0	40.0	600	3	15 x 9 x 5

inal cost. Higher tolerances can be supplied at a slight increase in price. The size of any delay line depends upon the delay, rise time, impedance, and number of taps. But, as a practical guide, the volume for any line up to 100 μ s is .75 (delay/rise time) cubic inches. This size can be reduced for compact lines or increased for lower cost commercial devices. All lumped lines are hermetically sealed in a metal case or cast in a filled epoxy resin.

MINIATURE DELAY LINES



Miniature Lumped Constant Lines are generally cast in a filled epoxy resin capable of withstanding the environmental requirements of missiles and other electronic equipment. This method of sealing makes this series ideally suited for printed circuit and computer ap-

MODEL	DELAY in μ secs	RISE TIME in μ secs	IMPEDANCE in ohms	ATT in db	CASE SIZE
D277	15.0	.9	500	2.0	5-1/8 x 1 x 1/2
D286	.5	.05	1000	1.0	3-1/2 x 1/2 x 1/2
D226	12.0	1.0	1000	2.0	1-3/4 x 1 x 1
D154	.5	.1	300	.75	1 x 2 x 3/8
D117	1.37	.1	500	1.5	4 x 1-1/4 x 3/8
D129	2.4	.15	300	1.0	5 x 1-1/2 x 3/8

plications. The delay lines in this series can be tapped as required and are often supplied with taps every section. Printed circuit leads can be supplied for plug-in applications. The general characteristics of the standard lumped constant series can also be applied to the miniature group.

The above is only a partial listing and is typical of the results that can be expected. Generally, lumped constant delay lines are custom made. The delay time, tap spacing, impedance, rise time, distortion, and attenuation

are tailored to meet the specific customer's requirement. All CDC delay lines are manufactured to meet the rigid MIL Specs for ship, land, aircraft, and missile equipment.

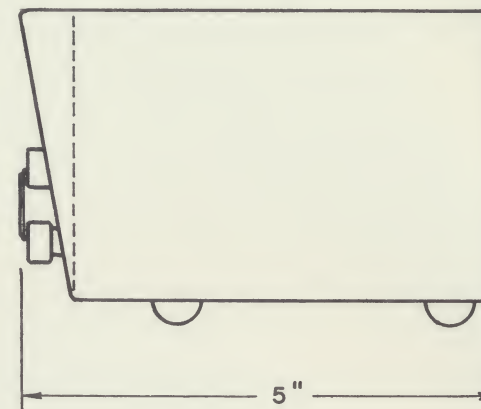
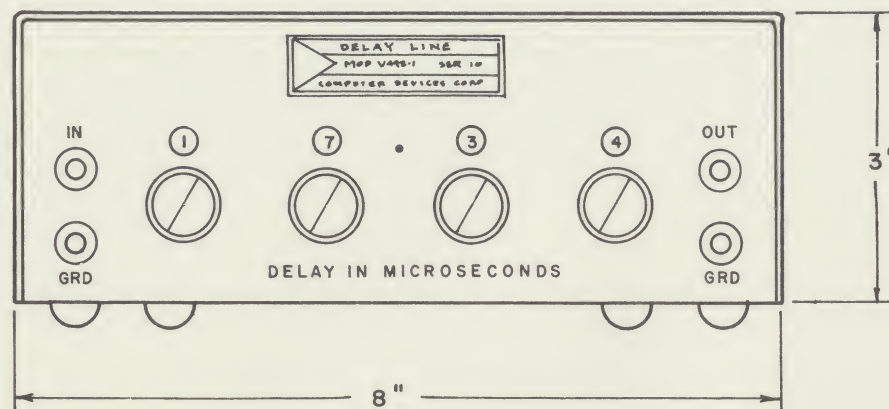
CDC welcomes the opportunity to serve you - to assist in specifying and solving your delay line problems. We offer prompt response to your inquiries - rapid delivery of samples, usually two to three weeks - and quality assured production units.

COMPUTER DEVICES CORP.

TEL: AR 1-0666

6 WEST 18 STREET HUNTINGTON STATION, N.Y.



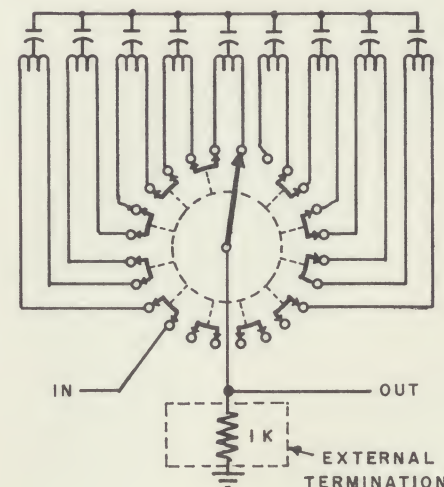


NOTES: EQUIPMENT HAS GRAY HAMMERTONE FINISH AND IS EQUIPPED WITH FOUR RUBBER FEET.

MULTI-PURPOSE BANANA PLUG RECEPTACLES PROVIDED FOR SIGNAL AND GROUND CONNECTIONS.

TABLE OF ELECTRICAL SPECIFICATIONS

MODEL	V492 -1	V492 -2	V492 -3	V492 -4
DELAY RANGE MICROSECONDS	0 19.99	0 29.99	0 9.99	0 99.99
DELAY INCREMENTS MICROSECONDS	.01	.01	.01	.01
RISE TIME MICROSEC. AT MAX. DELAY	0.5	0.7	0.3	3.0
IMPEDANCE INPUT & OUTPUT (OHMS)	1000	1000	1000	1000
ATTENUATION DB MAX.	5	6	3	3
DISTORTION	10 %	10 %	10 %	10 %



SCHEMATIC
DIAGRAM
(SHOWING ONE SECTION)

MODEL V492-3 HAS THREE SECTIONS (SWITCHES)

ALL OTHER MODELS HAVE FOUR SECTIONS (SWITCHES) AS SHOWN ON OUTLINE DRAWING ABOVE.

DELAY LINE, VARIABLE,
DIRECT READOUT
(INSTRUMENT TYPE)
MODEL V492

COMPUTER DEVICES
CORP.

6 WEST 18-TH ST.
HUNTINGTON STA., N.Y.

SCALE 1/2" = 1"

DWN *Rat* 9/18/63

APPVD *E.W.*

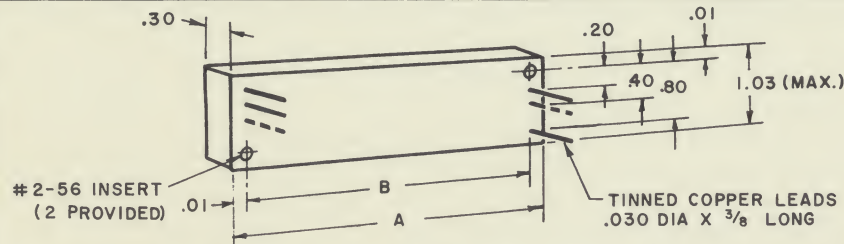
CHKD *K. Dunne*

A

49201

SIZE DWG NO.

REV.



GENERAL SPECIFICATIONS:

1. DELAY TOLERANCE: $\pm 5\%$
2. TEMP. COEFFICIENT: 50 PPM
3. CONSTRUCTION: HERMETICALLY SEALED METAL CASE, GRAY LACQUER FINISH.
4. MILITARY SPECS: DESIGNED TO MEET ALL APPLICABLE MILITARY SPECIFICATIONS FOR WORKMANSHIP AND ENVIRONMENTAL COND'S.

NOTES:

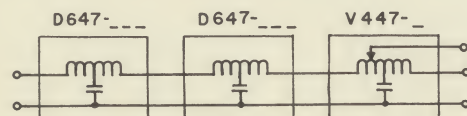
1. MODULES OF 4.35 μ SEC ARE TAPPED AT 1.45 AND 2.90 μ SEC.
2. DESIGNED FOR CASCADED IN SERIES TO OBTAIN LONGER DELAYS AND WITH THE V447 (VARIABLE) TO OBTAIN A TRIMABLE DELAY.

CASE SIZE NO. 1 (A = 1.25 B = 1.00)						CASE SIZE NO. 2 (A = 2.20 B = 2.00)						CASE SIZE NO. 3 (A = 3.45 B = 3.20)					
PART NO.	DELAY	T _R	IMPED.	ATTEN.	TAP.	PART NO.	DELAY	T _R	IMPED.	ATTEN.	TAP.	PART NO.	DELAY	T _R	IMPED.	ATTEN.	TAP.
D647-110	50 nSEC	12 nSEC	50 Ω	1 db	NONE	D647-210	50 nSEC	6.2 nS	50 Ω	1 db	NONE	D647-310	50 nSEC	4.2 nS	50 Ω	1 db	NONE
-111	100	25				-211	100	12.5				-311	100	8.3			
-112	250	62				-212	250	31.1				-312	250	21			
-113	500	125				-213	500	62				-313	500	42			
-114	750	187				-214	750	94				-314	750	63			
-115	1.00 μ SEC	.25 μ SEC				-215	1.00 μ SEC	.12 μ SEC				-315	1.00 μ SEC	.08 μ SEC			
-116	1.45	.36				-216	1.45	.18				-316	1.45	.12			
-117	2.90	.72		2 db	1.45 μ S	-217	2.90	.36		2 db	1.45 μ S	-317	2.90	.24		2 db	1.45 μ S
-118	4.35	1.10		3 db	NOTE 1	-218	4.35	.54		3 db	NOTE 1	-318	4.35	.36		3 db	NOTE 1
D647-120	50 nSEC	12 nSEC	150 Ω	1/2 db	NONE	D647-220	50 nSEC	6.2 nS	150 Ω	1/2 db	NONE	D647-320	50 nSEC	4.2 nS	150 Ω	1/2 db	NONE
-121	100	25				-221	100	12.5				-321	100	8.3			
-122	250	62				-222	250	31.1				-322	250	21			
-123	500	125				-223	500	62				-323	500	42			
-124	750	187				-224	750	94				-324	750	63			
-125	1.00 μ SEC	.25 μ SEC				-225	1.00 μ SEC	.12 μ S				-325	1.00 μ SEC	.08 μ S			
-126	1.45	.36		1 db		-226	1.45	.18		1 db		-326	1.45	.12		1 db	
-127	2.90	.72		1 1/2 db	1.45 μ S	-227	2.90	.36		1 1/2 db	1.45 μ S	-327	2.90	.24		1 1/2 db	1.45 μ S
-128	4.35	1.10		2 db	NOTE 1	-228	4.35	.54		2 db	NOTE 1	-328	4.35	.36		2 db	NOTE 1
D647-130	50 nSEC	12 nSEC	500 Ω	1/2 db	NONE	D647-230	50 nSEC	6.2 nS	500 Ω	1/2 db	NONE	D647-330	50 nSEC	4.2 nS	500 Ω	1/2 db	NONE
-131	100	25				-231	100	12.5				-331	100	8.3			
-132	250	62				-232	250	31.1				-332	250	21			
-133	500	125				-233	500	62				-333	500	42			
-134	750	187				-234	750	94				-334	750	63			
-135	1.00 μ SEC	.25 μ SEC				-235	1.00 μ SEC	.12 μ S				-335	1.00 μ SEC	.08 μ S			
-136	1.45	.36		1 db		-236	1.45	.18		1 db		-336	1.45	.12		1 db	
-137	2.90	.72		1 1/2 db	1.45 μ S	-237	2.90	.36		1 1/2 db	1.45 μ S	-337	2.90	.24		1 1/2 db	1.45 μ S
-138	4.35	1.10		2 db	NOTE 1	-238	4.35	.54		2 db	NOTE 1	-338	4.35	.36		2 db	NOTE 1

CASE SIZE NO. 1 (A = 1.25 B = 1.00)

CASE SIZE NO. 2 (A = 2.20 B = 2.00)

CASE SIZE NO. 3 (A = 3.45 B = 3.20)



TYPICAL CASCADED GROUP
(WITH V447 TRIM DELAY)

RISE TIME: TO CALCULATE RISE TIME FOR GROUPS CASCADED IN SERIES, USE THE FOLLOWING FORMULA:

$$T_R = \frac{D}{100} + T_{RM}$$

WHERE T_R IS THE RISE TIME FOR THE GROUP, T_{RM} IS THE RISE TIME OF THE MODULE WITH THE HIGHEST RISE TIME OF THOSE USED.

DELAY LINE,
ULTRAMINIATURE,
FIXED.
SERIES D647

COMPUTER DEVICES
CORP.
6 WEST 18th ST.
HUNTINGTON STA., N.Y.

SCALE NONE

DWN NK 4/6/64

APPVD E.S.W.

CHKD K. Dume

A 64701

SIZE DWG. NO.

REV.



AUDIO

DELAY

COMPENSATION

LINE



DA 324

The DA 324 is a high performance audio frequency variable Delay Line designed specifically for use in data communications systems to compensate for delay shifts caused by unequal lengths of wire communication lines. The DA 324 has a delay of 400 microseconds with delay setting adjustable to any delay in this range in steps

of 1 microsecond.

The DA 324 also accepts a companion delay extension unit, the DA 324C with a delay of 600 microseconds, which is coupled directly to the controls of the DA 324, thus providing a combination having a total delay of 1000 usec adjustable in 1 usec steps.

MODEL	DA 324	DA 324 & DA 324C Combined
Delay	400 usec	1000 usec
Resolution	1 usec	1 usec
Rise time at maximum delay	11 usec max	12 usec max
Input impedance	600 ohms	600 ohms
Output impedance	600 ohms	600 ohms
Voltage standing wave ratio	<.5 db to 30 kc <3 db to 50 kc	<.5 db to 27 kc <3 db to 45 kc
Insertion loss	1 db max	3 db max
Temperature stability	50 PPM/°C	50 PPM/°C
Phase linearity	<1/2%	<1/2%
Ripple or distortion	<10% of Signal	<10% of Signal
Size	3 1/2 X 19 Rack Panel X 10" Deep	2 Panels same as DA 324

The Delay setting is accomplished by three decade, insertion type switches with a numerical display reading directly in microseconds. These controls are normally mounted in the rear of the unit to forestall tampering, or as a front panel display.

When ordering specify:

- | | |
|---------------------------|-------------------------------|
| 1. Location of Controls | — Front panel or rear of unit |
| 2. Type of Controls | — Knob or screwdriver slot |
| 3. Location of Connectors | — Front panel or rear of unit |
| 4. Type of Connectors | — BNC or binding posts |

COMPUTER DEVICES CORP.

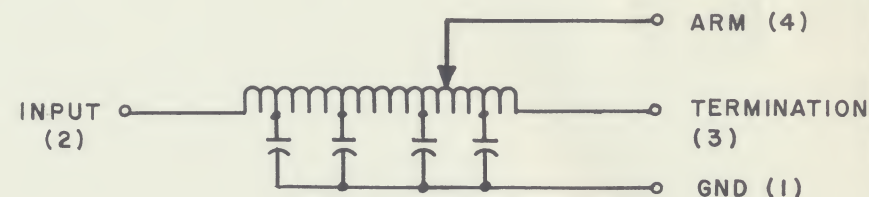
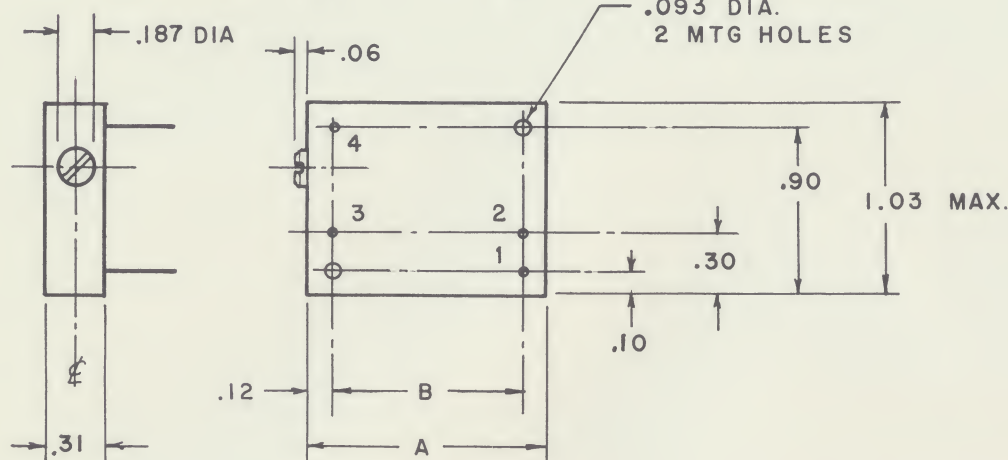
TEL: 516 AR 1-0666

6 WEST 18 STREET HUNTINGTON STATION, N.Y.



THOMAS M. GARRETTSON CO.
BRANCH OFFICE
714 HAMBURG TPK. POMPTON LAKES, N. J.
PHONE 835-3366 AL LOSPINOSO

TINNED COPPER
LEADS, .020 DIA.
3/8" LONG



CIRCUIT DIAGRAM

GENERAL SPECIFICATIONS

TEMP. COEFF: 50 PPM

CONSTRUCTION: HERMETICALLY SEALED METAL CASE WITH GRAY LACQUER FINISH.

CONTROL: DELAY IS SET BY MULTI-TURN SCREW DRIVER CONTROL. .125 DIA. SHAFT FOR KNOB APPLICATION PROVIDED ON SPECIAL ORDER

MIL SPECS: DESIGNED TO MEET ALL APPLICABLE MILITARY SPECIFICATIONS FOR WORKMANSHIP AND ENVIRONMENTAL CONDITIONS.

TABLE OF ELECTRICAL SPECIFICATIONS
(AND CORRESPONDING DIMENSIONS)

MODEL	V447 -1	V447 -2	V447 -3	V447 -4	V447 -5	V447 -6
DELAY RANGE NANOSECONDS	0 TO 55	0 TO 100	0 TO 150	0 TO 250	0 TO 300	0 TO 500
RISE TIME NANOSEC AT MAX.DELAY	15	30	25	30	30	60
IMPEDANCE OHMS	150	50	150	50	150	50
ATTENUATION DB MAX.	1	1	1	1.5	1.5	2
RESOLUTION	1/110	1/150	1/250	1/250	1/500	1/500
LENGTH (A)	1.25	1.25	2.45	2.45	3.45	3.45
MTG DIM. (B)	1.00	1.00	2.20	2.20	3.20	3.20

DELAY LINE,
ULTRAMINIATURE
VARIABLE
MODEL V447

COMPUTER DEVICES
CORP.

6 WEST 18 TH ST.
HUNTINGTON STA., N.Y.

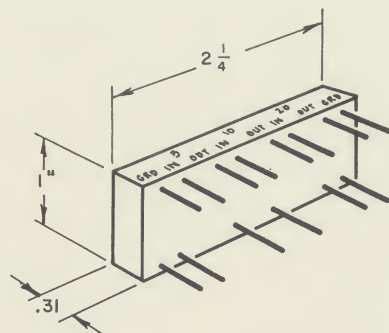
SCALE FULL DWN NK. 3/4/63

APPVD E.W. CHKD K.D.

A 44701

SIZE DWG. NO.

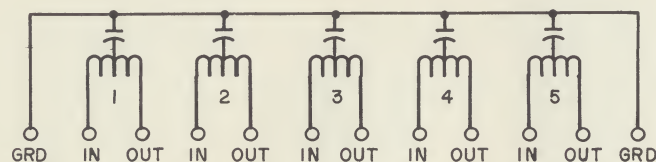
REV.



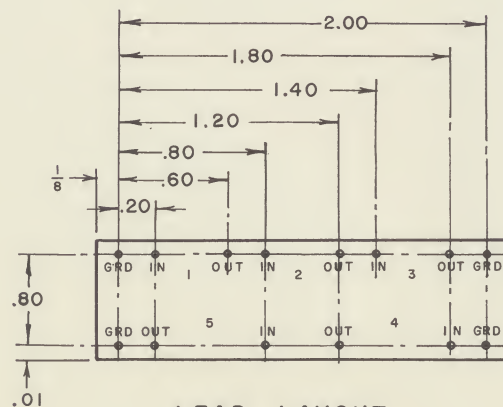
MODELS:
D 740
D 741
D 742
D 743

MULTIPLE SECTION DELAY LINES

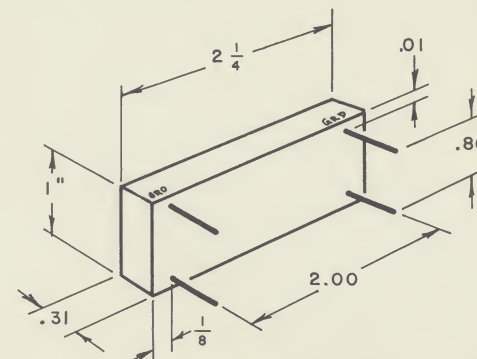
TIME DELAY (PER SECTION) NANOSECONDS					TOTAL TIME DELAY (WITH ALL SECTIONS CONNECTED IN SERIES)	RISE TIME NANOSECS	IMPEDANCE	
1	2	3	4	5			93 Ω MODEL NO.	330 Ω MODEL NO.
5	10	20	30	40	105 NANOSECONDS	15 *	D 740	D 741
50	100	200	300	400	1050 NANOSECONDS	150 *	D 742	D 743



SCHEMATIC DIAGRAM



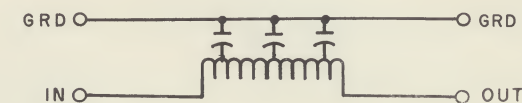
LEAD LAYOUT



MODELS:
D 744
D 745
D 746
D 747

SINGLE SECTION DELAY LINES

TIME DELAY NANOSECONDS	RISE TIME NANOSECS	IMPEDANCE	
		93 Ω MODEL NO.	330 Ω MODEL NO.
100	15 *	D 744	D 745
1000	150 *	D 746	D 747



SCHEMATIC DIAGRAM

NOTES:

1. RISE TIME, WHEN SEVERAL MODULES ARE CASCADED IN SERIES, CAN BE DETERMINED BY THE FOLLOWING FORMULA: $T_R = \frac{D}{100} + T_{RM} *$. WHERE T_R IS THE RISE TIME OF THE COMBINATION OF MODULES IN MICROSECONDS, $T_{RM} *$ IS THE RISE TIME OF A SINGLE MODULE AS INDICATED. WHEN MODULE TYPES ARE MIXED, USE HIGHER $T_{RM} *$.
2. ATTENUATION = $1/2$ DB PER MODULE.
3. DELAY ACCURACY IS BETTER THAN 5%.
4. RIPPLE IS LESS THAN 5%.
5. TERMINALS ARE .025 DIA. DUMET (GOLD PLATED) LEADS, $1/2$ LONG.
6. TEMPERATURE COEFFICIENT IS .05% OF TOTAL DELAY PER $^{\circ}\text{C}$ OVER THE TEMPERATURE RANGE OF -60°C TO $+125^{\circ}\text{C}$.
7. UNITS ARE ENCAPSULATED IN EPOXY RESIN AND HAVE BLACK FINISH.

DELAY LINES,
NANOSECOND
"DO-IT-YOURSELF"
D740 THRU D747
(LUMPED CONSTANT)

COMPUTER DEVICES
CORP.
6 WEST 18th ST
HUNTINGTON STA., N.Y.

SCALE NONE DWN N.K. 2/24/64
APPVD F.W. CHKD K.W. 2/24/64

A 74001
SIZE DWG NO.

REV.

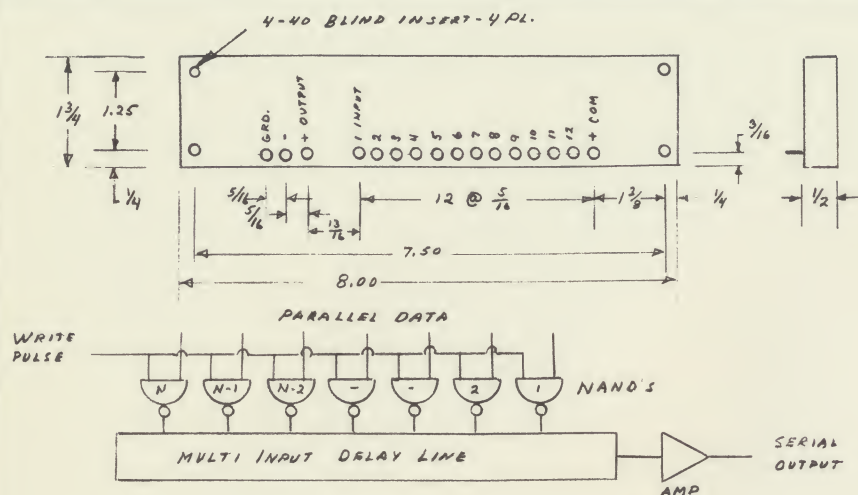


FIG. 1 FUNCTIONAL DIAGRAM

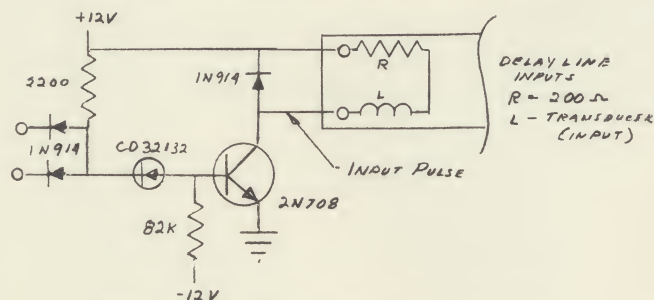


FIG. 2 APPLICATION CIRCUIT (NAND)

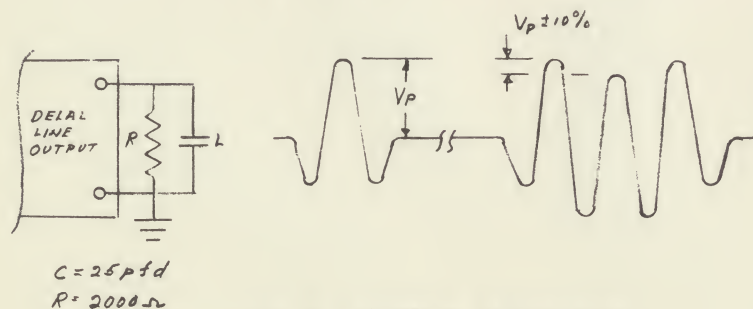


FIG. 3 OUTPUT WAVEFORMS

CODE GENERATOR

Delay Line Model DM718 is representative of a series of multi-tapped Magnetostrictive Delay Lines that are intended for use as word generators, serial to parallel or parallel to serial converters in digital computers or as recognition code train generators in radar systems. A wide choice of tap spacings and number of taps is available with tap spacings from .2 usec to several hundred microseconds being readily achievable. As many as 16 taps at a spacing of 1 usec are provided in the same case size as that of the DM718.

Electronic circuits to restore the signals to input logic level and to match system requirements are also supplied.

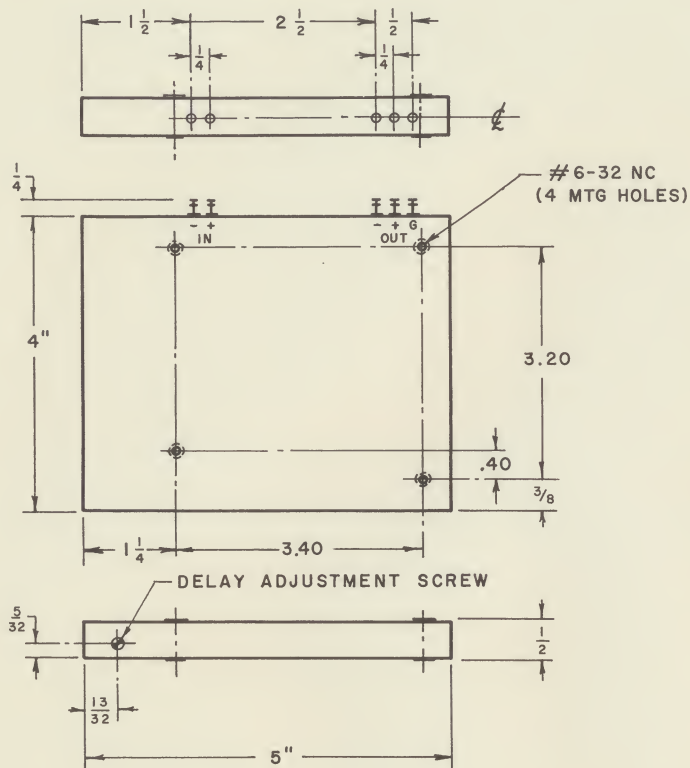
Specifications for Delay Line Model DM718

- 1.0 General Description
Delay Line Model DM718 is a 12 input Magnetostrictive Delay Line intended as a real time parallel to serial converter. Ref. Fig. 1.
- 2.0 Electrical Specifications
 - 2.1 Input Ref. Fig. 2
 - 2.2 Input pulse width: 0.40 $\pm$ 0.05 usec.
 - 2.3 Input rise and fall time: 0.05 usec Max.
 - 2.4 Output Ref. Fig. 3
 - 2.5 Output amplitude (V_p): 20 mv Min.
 - 2.6 Signal/Noise Ratio: 5:1 Min.
 - 2.7 Amplitude variation: $\pm$ 10% Max.
 - 2.8 Crosstalk between inputs and outputs: Less than 1 to 3
- 3.0 Delay Specifications:
 - 3.1 Tap Spacing (at 25°C): 1.25 usec $\pm$ 0.05 usec
 - 3.2 Tap #1 to Output: 1.75 usec $\pm$ 0.25 usec
 - 3.3 Number of Input taps: 12
- 4.0 Environmental
 - 4.1 Operating Temperature Range: 0 to 50°C
 - 4.2 Storage Temperature Range: -55 to +85°C
 - 4.3 Applicable Mil. specifications: Mil. Std. 202B
 - 4.3.1 Method 102A: Test Condition D
 - 4.3.2 Method 103A: Test Condition B
 - 4.3.3 Method 201A
 - 4.3.4 Method 202A: 50 g 1 blow
- 5.0 Construction and Marking
 - 5.1 Construction: Solder sealed steel case
 - 5.2 Weight: 8 oz.
 - 5.3 All taps shall have a common return

COMPUTER DEVICES CORP.
6 WEST 18 STREET
HUNTINGTON STA., NEW YORK

CODE GENERATOR
Delay Line Model DM718

MAT.		DATE
DWG		REV.



SPECIFICATIONS

Delay: Choice of any delay between 50 and 1500 usec.

Delay adjustment: ± 3 usec from specified nominal.

Pulse repetition frequency: 700 Kcs to 1.2 Mcs RZ (specify your requirement)

C. W. Bandwidth: 500 Kcs to 1.5 Mcs

Input Impedance: 300 ohms

Input Current: 40 to 50 ma

Input Pulse Width: Depends on bit rate (.4 usec for 1 ^{mic}ma)

Output: Terminated in 2000 ohms and 50 picofarads

Output Voltage: 25 millivolts at 500 usec
15 millivolts at 1500 usec

Temperature Stability: 1 PPM/ $^{\circ}$ C (0 to 50 $^{\circ}$ C)

Construction: Aluminum case - gold anodized finish

Price: 1 through 30 pieces - \$70.00 each

Accessories

Transistorized input and output electronics. Mounts directly on DM544 case (adds 5/8" to thickness of unit). Provides unity gain to input signal.

Power required: +12 VDC
-12 VDC

Input Pulse Amplitude: grd to +5 volts

Price: 1 - 30 pieces - \$75.00 each

DELAY LINE,
MAGNETOSTRICTIVE
SERIES DM 544

COMPUTER DEVICES
CORP.
6 WEST 18th ST.
HUNTINGTON STA., N.Y.

SCALE

—

DWN

NK 3/31/64

APPVD

E.W.

CHKD

H. Dumas

A

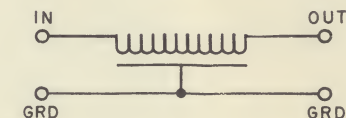
SIZE

54401

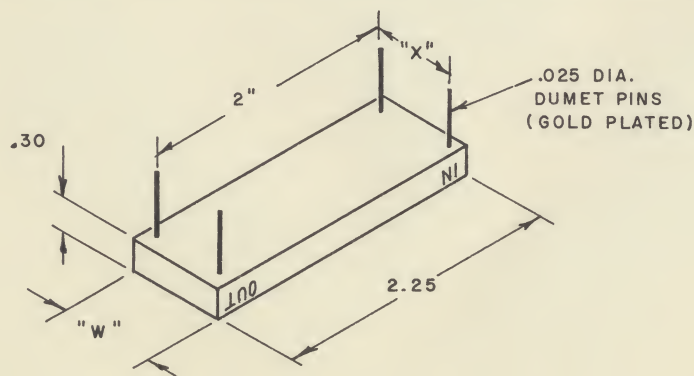
DWG NO.

REV

CASE SIZE	DELAY NANOSECONDS	RISE TIME NANOSECONDS	IMPEDANCE = 93Ω (PART NUMBER)	IMPEDANCE = 330Ω (PART NUMBER)	IMPEDANCE = 500Ω (PART NUMBER)	IMPEDANCE = 1000Ω (PART NUMBER)
"W" = .50" "X" = .20"	5	1.0	DD680-110	DD680-120	DD680-130	DD680-140
	10	2.0	-111	-121	-131	-141
	20	4.0	-112	-122	-132	-142
	30	6.0	-113	-123	-133	-143
	40	8.0	-114	-124	-134	-144
	50	10.0	-115	-125	-135	-145
	60	12.0	-116	-126	-136	-146
	70	14.0	-117	-127	-137	-147
	80	16.0	-118	-128	-138	-148
	90	18.0	-119	-129	-139	-149
	100	20.0	-11X	-12X	-13X	-14X
"W" = 1.00" "X" = .80"	5	0.5	DD680-210	DD680-220	DD680-230	DD680-240
	10	1.0	-211	-221	-231	-241
	20	2.0	-212	-222	-232	-242
	30	3.0	-213	-223	-233	-243
	40	4.0	-214	-224	-234	-244
	50	5.0	-215	-225	-235	-245
	60	6.0	-216	-226	-236	-246
	70	7.0	-217	-227	-237	-247
	80	8.0	-218	-228	-238	-248
	90	9.0	-219	-229	-239	-249
	100	10.0	-21X	-22X	-23X	-24X



NOTE: FOR SIMILAR TYPE DELAY LINE WITH DELAY IN MICROSECONDS, SEE DWG. A67901.



GENERAL SPECIFICATIONS:

DELAY TOLERANCE: $\pm 5\%$
 ATTENUATION: LESS THAN $\frac{1}{2}$ DB PER 100 NANOSECONDS
 RIPPLE: 10% MAXIMUM.
 IMPEDANCE TOLERANCE: $\pm 10\%$
 TEMPERATURE COEFFICIENT: 100 TO 150 PPM/ $^{\circ}$ C
 TEMPERATURE RANGE: -50° C TO $+125^{\circ}$ C
 PRINTED CIRCUIT TYPE, LEAD MOUNTING, EPOXY CASE
 MEETS APPLICABLE MILITARY SPECIFICATIONS

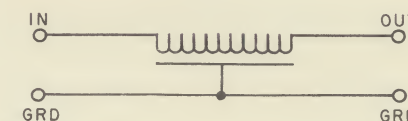
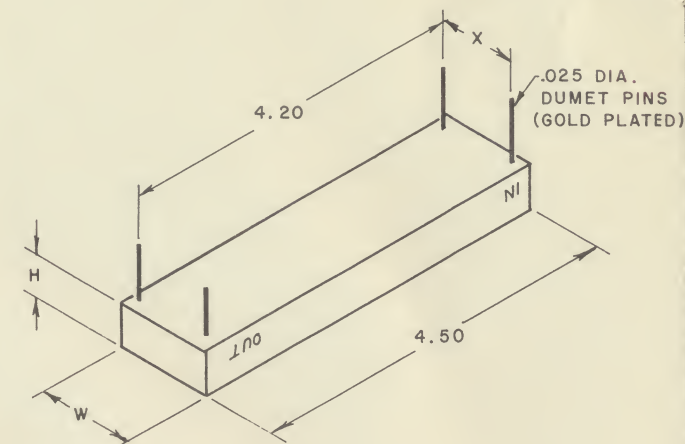
DELAY LINE,
 NANOSECOND,
 MODULE
 SERIES DD680
 (DISTRIBUTED CONSTANT)

COMPUTER DEVICES
 CORP.
 6 WEST 18th ST.
 HUNTINGTON STA., N. Y.

SCALE NONE DWN NK 2/24/64
 APPVD E.W. CHKD Kenton

SIZE A 68001
 DWG. NO. REV.

CASE SIZE	DELAY MICROSECONDS	RISE TIME MICROSECONDS	IMPEDANCE 330 Ω (MODEL NO.)	IMPEDANCE 500 Ω (MODEL NO.)	IMPEDANCE 1000 Ω (MODEL NO.)	IMPEDANCE 3900 Ω (MODEL NO.)
H = .37 W = .50 X = .20	0.1	.02	DD679-111	DD679-121	DD679-131	
	0.2	.04	-112	-122	-132	
	0.3	.06	-113	-123	-133	
	0.4	.08	-114	-124	-134	
	0.5	.10	-115	-125	-135	
	0.6	.12	-116	-126	-136	
	0.7	.14	-117	-127	-137	
	0.8	.16	-118	-128	-138	
	0.9	.18	-119	-129	-139	
	1.0	.20	-11X	-12X	-13X	
H = .50 W = .50 X = .20	2.0	.4		DD679-222	DD679-232	DD679-242
	4.0	.8		-224	-234	-244
	5.0	1.0		-225	-235	-245
	10.0	2.0		-22X	-23X	-24X
H = .37 W = 1.00 X = .80	0.1	.01	DD679-311	DD679-321	DD679-331	
	0.2	.02	-312	-322	-332	
	0.3	.03	-313	-323	-333	
	0.4	.04	-314	-324	-334	
	0.5	.05	-315	-325	-335	
	0.6	.06	-316	-326	-336	
	0.7	.07	-317	-327	-337	
	0.8	.08	-318	-328	-338	
	0.9	.09	-319	-329	-339	
	1.0	0.1	-31X	-32X	-33X	
H = .50 W = 1.00 X = .80	2.0	0.2		DD679-422	DD679-432	DD679-442
	4.0	0.4		-424	-434	-444
	5.0	0.5		-425	-435	-445
	10.0	1.0		-42X	-43X	-44X



NOTE: FOR SIMILAR TYPE DELAY LINE WITH DELAY IN NANoseconds, SEE DWG A68001.

GENERAL SPECIFICATIONS:

DELAY TOLERANCE: $\pm 5\%$
 ATTENUATION: LESS THAN $\frac{1}{2}$ DB PER MICROSECOND
 RIPPLE: 10% MAXIMUM
 IMPEDANCE TOLERANCE: $\pm 10\%$
 TEMPERATURE COEFFICIENT: 100 TO 150 PPM/ $^{\circ}$ C
 TEMPERATURE RANGE: -50° C TO $+125^{\circ}$ C
 PRINTED CIRCUIT TYPE, LEAD MOUNTING, EPOXY CASE
 MEETS APPLICABLE MILITARY SPECIFICATIONS

DELAY LINE,
 MICROSECOND,
 MODULE

SERIES DD679
 (DISTRIBUTED CONSTANT)

COMPUTER DEVICES
 CORP.

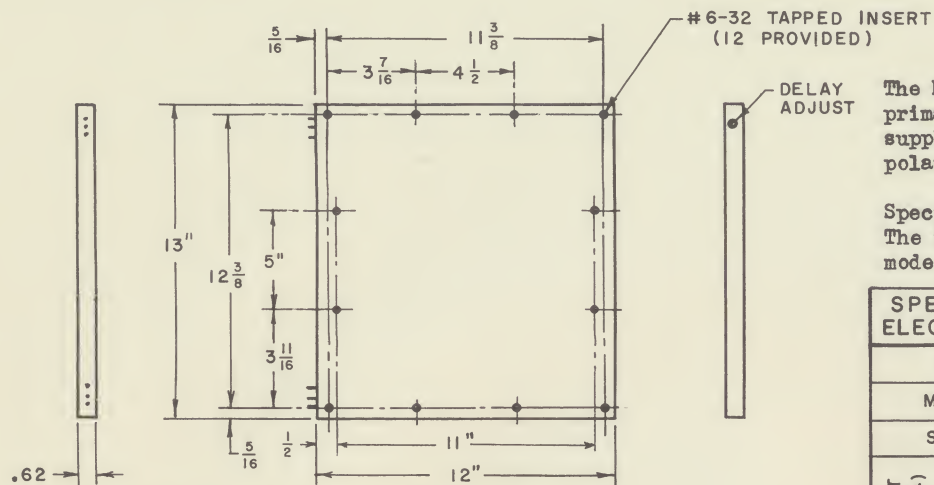
6 WEST 18th ST.
 HUNTINGTON STA., N.Y.

SCALE NONE
 APPVD E. W.
 DWN NK. 4/13/64
 CHKD Ken P.

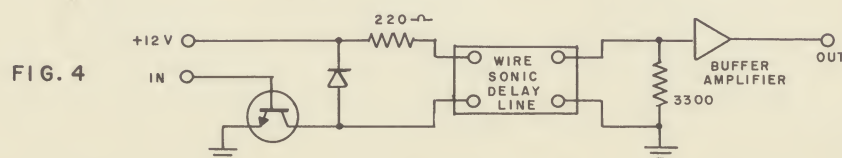
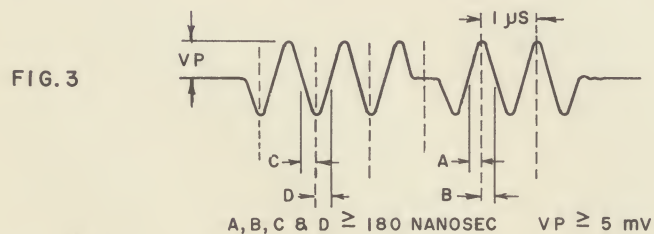
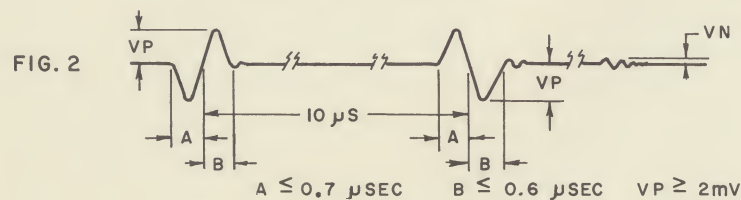
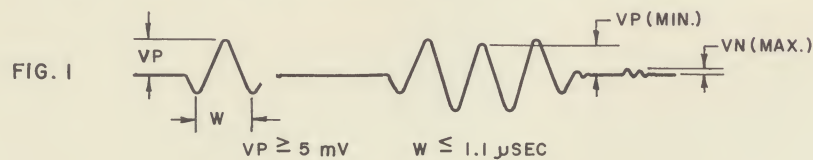
A 67901

SIZE DWG NO.

REV.



NOTE: FOR CIRCUIT MOUNTING ACCESSORIES, SEE DWG. A77602



WIRE SONIC DELAY LINE MODEL MT766 (For Delays 5 to 12 Millisec)

The MT766 Wire Sonic Delay Line provides delays of up to 12,000 usec and is primarily designed for use in digital computers as a storage medium. It is supplied for recording in any of the three standard modes: RZ, NRZ and Bi-polar, and the intended mode of operation must be specified when ordering.

Specifications and electrical characteristics vary with operating frequency. The following specifications are for maximum delay at maximum bit rate for mode indicated.

SPECIFICATIONS AND ELECT. CHARACTERISTICS		RECORDING MODE		
		RZ	NRZ	BIPOLAR
MAXIMUM DELAY		10,000 USEC	10,000 USEC	12,000 USEC
MAXIMUM BIT RATE		1 MC	2 MC	1 MC
STORAGE CAPACITY		10,000 BITS	20,000 BITS	12,000 BITS
INPUT (FIG. 4)	VOLTAGE	12 V	12 V	12 V
	PULSE WIDTH	0.4 USEC	10 USEC (SEE FIG. 2)	0.4 USEC
	CURRENT	50 mA	50 mA	50 mA
OUTPUT (FIG. 4)	LOAD	3300 OHMS	3300 OHMS	3300 OHMS
	PULSE WIDTH	SEE FIG. 1	SEE FIG. 2	SEE FIG. 3
	MINIMUM VOLTAGE	5 mV	2 mV	5 mV
	SIGNAL TO NOISE $\frac{VP}{VN}$	STATIC 12:1	7:1	N/A
		DYNAMIC 5:1	4:1	N/A

TEMP. VARIATIONS		5 MILLISEC LINE	10 MILLISEC LINE
DRIFT	10 TO 40°C	0.1 USEC MAX.	0.2 USEC MAX.
	0 TO 50°C	0.25 USEC MAX.	0.5 USEC MAX.

Amplitude Temperature Dependence: $\frac{VP_{\text{Max.}} - VP_{\text{Min.}}}{VP_{\text{Max}}} \times 100\% \leq 20\%$

Storage Temperature: -65 to +100°C

Mechanical Construction:

Solder sealed steel case with "O" ring seal on adjustment shaft.
Finished with gray lacquer per Mil-E-15090.

DELAY LINE,
WIRE SONIC
MODEL MT766

COMPUTER DEVICES
CORP.
6 WEST 18th ST.
HUNTINGTON STA., N. Y.

SCALE NONE DWN *Rud 5/22/64*
APPVD E.S.W. CHKD *Kan Damm*

A 76601
SIZE DWG NO.

REV.

STANDARD CDC

SONIC DELAY LINE MEMORIES

FOR DIRECT COMPUTER APPLICATION

THE CDC SONIC DELAY LINE MEMORIES ARE COMPLETE DYNAMIC STORAGE DEVICES CAPABLE OF ANY CAPACITY FROM 10 BITS TO 20,000 BITS. THESE MEMORIES UTILIZE A MAGNETOSTRICTIVE DELAY LINE AS THE STORAGE MEDIUM AND INCLUDE ASSOCIATED INPUT/OUTPUT CIRCUITRY, INPUT DRIVERS AND OUTPUT AMPLIFIERS, TO PROVIDE A COMPLETE RECIRCULATING MEMORY PACKAGE.

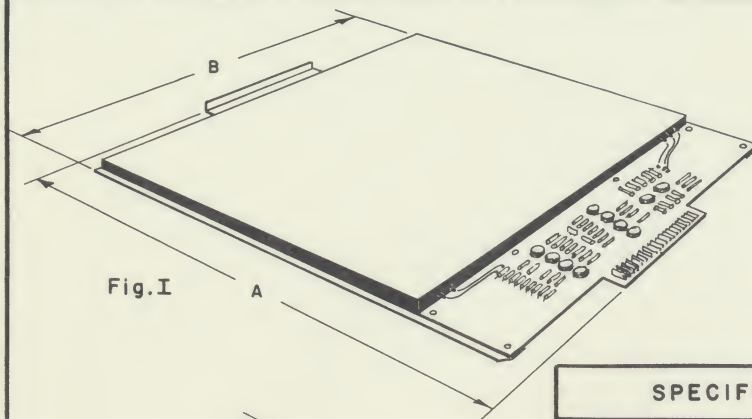


Fig. I

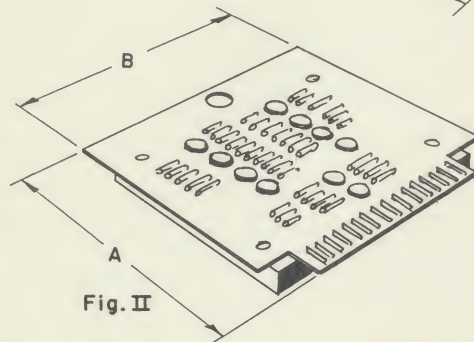
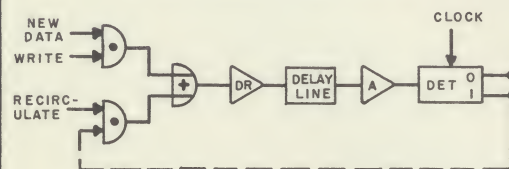


Fig. II

FUNCTIONAL DIAGRAM



SPECIFICATION		MODEL MS776A	MODEL MS774A	MODEL MS772A	MODEL MS890	MODEL MS892
MAXIMUM STORAGE CAPACITY (BITS) AND MAXIMUM CLOCK FREQUENCY (MC) (SEE NOTE 4)	NRZ *	20,000 @ 2 MC	10,000 @ 2 MC	5400 @ 2 MC	4000 @ 2 MC	2400 @ 2 MC
	RZ **	10,000 @ 1 MC	5000 @ 1 MC	2700 @ 1 MC	2000 @ 1 MC	1200 @ 1 MC
	BIPOLAR	12,000 @ 1 MC	6000 @ 1 MC	3000 @ 1 MC	2000 @ 1 MC	1200 @ 1 MC
DELAY RANGE		5 MS TO 12 MS	2 MS TO 6 MS	500 μ S - 2700 μ S	200 μ S - 2000 μ S	50 μ S - 1500 μ S
OPERATING TEMPERATURE	NRZ AND BIPOLAR	15° TO 40°C	5° TO 45°C	-5° TO +50°C	0° TO 60°C	-15° TO +60°C
	RZ	10° TO 45°C	0° TO 50°C	-15° TO +55°C	-15° TO +65°C	-35° TO +75°C
INPUT LOADING	DC INPUTS	+6 V TO +30 V AND -6 V TO -30 V				
	CLOCK INPUT	(NORMALLY) ONE LOGIC LEAD				
	CLOCK STABILITY	± 2 PPM	± 5 PPM	± 10 PPM	± 15 PPM	± 15 PPM
POWER REQUIREMENTS		1 WATT TYPICAL FOR +12V AND -12V SUPPLIES				
FIGURE NUMBER		I	I	II	II	II
OVERALL DIMENSIONS (INCHES)	LENGTH A	15.94	10.44	5.12	4.37	5.00
	WIDTH B	13.28	8.00	6.25	4.50	5.75
	THICKNESS	$\pm .25$.69	$\pm .25$.69	1.37	1.75	1.12
MATING CONNECTOR (SEE NOTE 2)		ELCO # 00-7008-035-139-001		ELCO # 00-6016-046-932	ELCO # 00-7008-035-139-001	

NOTES:

1. OUTLINE CONFIGURATIONS AND DIMENSIONS ARE STANDARD AS SHOWN. CLOCK FREQUENCY, NUMBER OF BITS STORED, DELAY TIME AND CIRCUITRY ARE ADJUSTED TO BE COMPATIBLE WITH CUSTOMER'S EQUIPMENT.
2. CIRCUIT BOARDS ARE PROVIDED WITH LOWER TIER PINS UNLESS OTHERWISE SPECIFIED BY CUSTOMER.
3. NON-STANDARD CONFIGURATIONS TO MEET SPECIAL DIMENSIONAL LIMITS ARE SUPPLIED FOR SPECIFIC APPLICATION.
4. ANY STORAGE CAPACITY AND FREQUENCY (BIT RATE) UP TO THE MAXIMUM SHOWN MAY BE SPECIFIED.

* NON RETURN TO ZERO
** RETURN TO ZERO

SONIC
DELAY LINE
MEMORIES

COMPUTER DEVICES
CORP.
6 WEST 18th ST.
HUNTINGTON STA., N.Y.

SCALE *NONE*

DWN *N.S.*

APPVD *JSW.*

CHKD *Ken Dumas*

A

77602

SIZE DWG NO.

REV

OSCILLATOR - Model MO-965 SPECIFICATION

The Model MO-965 Low Frequency Oscillator utilizes a Wire Sonic Delay Line as the frequency determining element. This ultra stable Delay Line is employed in a loop in which the loop delay represents one-half wave length ($\lambda/2$). The Oscillator frequency is therefore the reciprocal of the wavelength ($f = 1/\lambda$). A special transistor circuit is used in the loop to insure that the oscillator is initially triggered and to insure that no extraneous pulses are circulated in the loop.

Frequency Range:

Any frequency within a range from a fraction of a cycle up to 25 Kc is supplied with one package size.

Frequency Accuracy:

Frequency can be set to any required accuracy within measurable means. Because the time keeping delay line is provided with an external adjustment that is continuously variable by means of a screw with a resolution of approximately 0.17 usec per turn it is possible to adjust a 400 cps oscillator to $\pm 0.001\%$ with relative ease. The Model MO-965 has an adjustment range of ± 2 usec.

Frequency Stability:

The MO-965 oscillators are designed to a temperature stability of less than ± 0.5 ppm/°C over a temperature range of 0 to 50°C ($\pm 0.0025\%$). Figure 1 illustrates the various temperature effects possible. Curves A and B are the maximum limits and represent a maximum shift of $\pm 0.05\%$ over a 50°C range. Curve C represents best achievable results. On a yield basis 90% of all units can be held within $\pm 0.005\%$ deviation over a range of 0 to 50°C and 10% within $\pm 0.0025\%$.

Note: No long term frequency stability information is presently available, however, based on existing delay line data, it is anticipated that the delay shift shall be less than 0.1 usec for 10,000 hours. Frequency deviation due to mechanical vibration of this type Delay Line has been noted not to exceed ± 0.05 usec for a 20 G level between 55 to 2000 cps.

Electrically Variable:

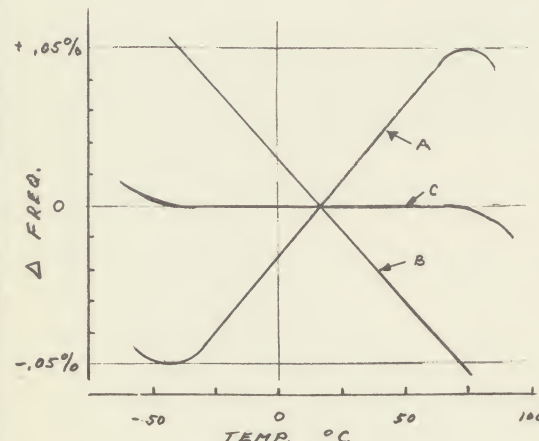
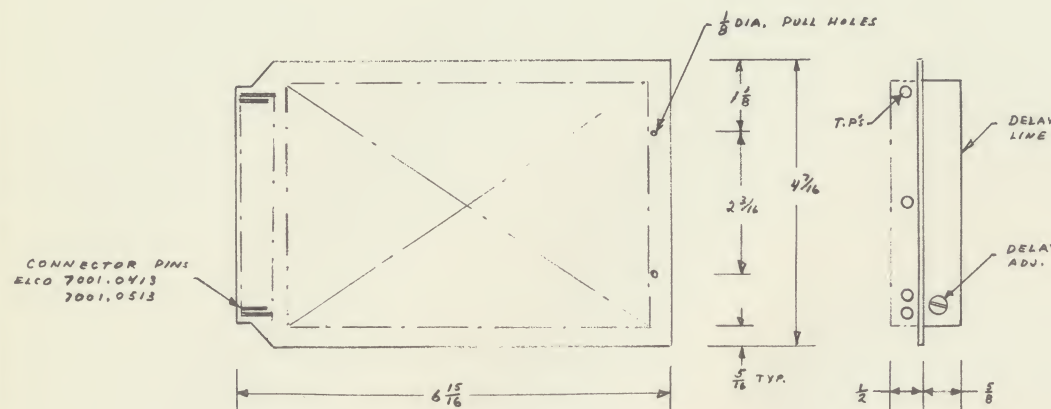
An electrically variable feature is optional. By encompassing a variable delay network in the Delay Line loop, it is possible to vary the frequency up to $\pm 25\%$ of its center frequency by means of an analog signal. The analog source must supply up to 5 ma of current. The response time of this variation is limited to one half the lowest frequency limit. The stability of this electrically variable feature can be held to within $\pm 0.05\%$ (0 to 50°C) by means of temperature compensation. The linearity (freq. vs applied voltage) can be held within $\pm 5\%$ - $\pm 2\%$ for a 10% deviation of the center frequency. See Figure 2.

Output

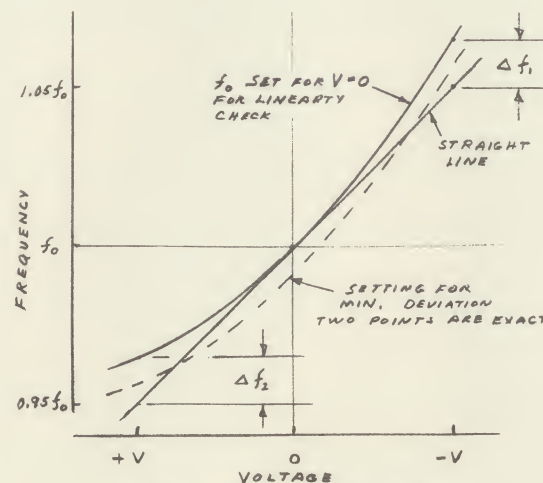
The output of this oscillator consists of two square waves 180° out of phase, with rise and fall times less than .1 usec. The output level is optional (up to 5 volts peak into 50 ohms).

DC Power

These units are designed for two dc supplies of 6 volts or more with regulation, ripple and noise restricted to $\pm 5\%$ of nominal.



TYPICAL TEMPERATURE VS FREQUENCY CURVES
FIG. 1



$$+2\% \leq \left(\frac{\Delta f_1}{.05 f_0} \right) \times 100\% \leq +5\%$$

$$+3\% \leq \left(\frac{\Delta f_2}{.05 f_0} \right) \times 100\% \leq +7\%$$

FIG. 2

PRELIMINARY DATA SHEET

COMPUTER DEVICES CORP. 6 WEST 18 STREET HUNTINGTON STA., NEW YORK	OSCILLATOR Model MO-965	MAT.	DATE
		DWG	REV.

The diagram shows two waveforms. The top waveform, labeled 'RZ INPUT WAVE FORM' and circled '1', is a periodic square wave with a high level and a low level. The bottom waveform, labeled 'DELAY LINE OUTPUT' and circled '2', is a periodic waveform that is a phase-shifted version of the input, showing a delay. A dashed horizontal line indicates the zero level for the output waveform.

[illegible]

NRZ INPUT
WAVE FORM
(1)

DELAY LINE
OUTPUT
(2)

Diagram illustrating the read operation:

- Two **WRITE AMPL'S** (amplifiers) feed into the **WIRE SONIC DELAY LINE**.
- The output of the **WIRE SONIC DELAY LINE** passes through a **READ AMPL** (amplifier).
- The output of the **READ AMPL** is connected to the **DETECTOR**.
- The output of the **DETECTOR** is connected to a circular component labeled **C**.

BIPOLAR INPUT WAVE FORM (1)

DELAY LINE OUTPUT (2)

MAT.		DATE
DWG	MOLS 10	REV.

COMPUTER DEVICES

A DELAY LINE PHASE SHIFTER FOR V.H.F.

REEL DELAY LINE
INFINITE-
RESOLUTION
CONSTANT-
IMPEDANCE
VARIABLE

Delay Line Has Infinite Resolution

New unit maintains
constant impedance at
all delay settings

By E. S. WENDOLKOWSKI
President, Computer Devices Corp.
Huntington Station, N. Y.

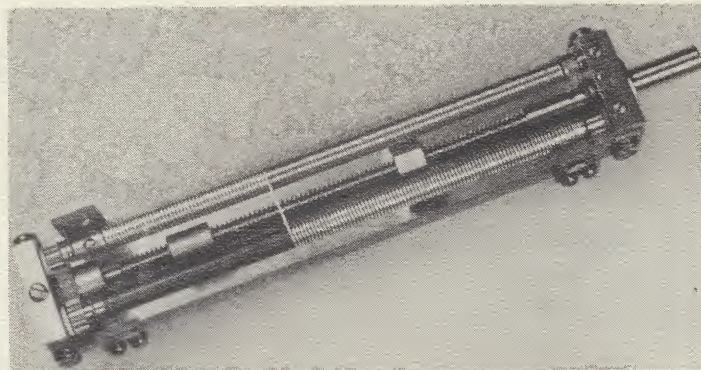
NEW APPROACH provides infinite resolution in a variable delay line; constant impedance is also maintained between input and output terminals at any delay setting.

Delay lines with infinite resolution, as contrasted with those having discrete tap settings, are especially useful in coordinating different waveforms. The new line has been used to correlate data coming from a multielement antenna and to adjust radar signals in time to feed a computer.

The length of this distributed-constant delay line is varied mechanically, eliminating mismatch problems associated with shorted turns in the usual distributor type delay line.

In effect, the new delay line acts as a multi-switch insertion-type delay line, wherein a series of switches disconnect unused portions of the delay line from the circuit. Both the new delay line and the multi-switch type maintain a constant impedance between input and output terminals.

The roller delay line uses the distributed constant principle wherein time delay is a function of inductance and capacitance: $T_d = \sqrt{LC}$. A silvered, then insulated, ceramic core is wrapped with a single-layer coil. The coil is inductive and capacitance is provided between the coil and the silver plating on the ceramic. Each increment of wire wound on the core provides an increment of inductance and capacitance, thereby providing an incre-



ROLLER-TYPE DELAY LINE varies delay by winding wire from delay-line mandrel (bottom) to shorting mandrel (top). Locknut (right center) provides positive, multi-turn stop to prevent damage to delay-line wire at either end—Fig. 1

ment of delay. Variation in delay is accomplished by winding and unwinding wire from the spool.

Mechanism—The delay line is composed of a delay-line mandrel, a shorting mandrel, and a drive system. The two mandrels are geared such that turning the drive shaft causes wire to wind from delay-line mandrel to shorting mandrel, or visa versa. The shorting mandrel is threaded to control the manner in which the wire is layered onto the delay-line mandrel.

A spring mechanism on the shorting mandrel maintains a constant tension on the wire.

Because the coil of wire is uninsulated, and the shorting mandrel is metal and also uninsulated, any inductance turns taken off the delay-line mandrel are shorted out. The removal of the slightest increment of wire removes a matched increment of capacitance and inductance, thus producing a corresponding change in delay. The delay adjustment is accomplished with infinite resolution at the impedance

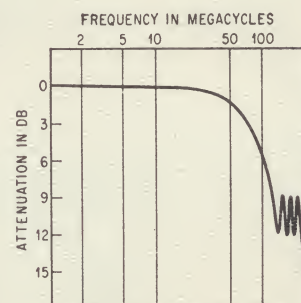
the same $1 \times 1\frac{1}{4} \times 5\frac{1}{2}$ -inch package size. Different delays and impedances are achieved by adjusting the thickness of the dielectric, changing wire size, changing pitch, and by varying the diameter and length of the mandrels.

Application—The new units are most useful where a delay trim adjustment between units of an existing system are required.

The constant impedance feature permits the delay line to be directly inserted into the interconnecting coaxial cables of the system without system modification or degradation.

At vhf, the line provides a means for introducing a phase shift at any frequency up to 200 Mc.

Extremely accurate phase settings can be made due to the infinite resolution feature of the roller delay line.



FREQUENCY RESPONSE of roller delay line is flat to 50 Mc. Vswr is less than 0.5 db to 45 Mc and less than 1 db from 45 Mc to 75 Mc. Beyond 75 Mc, vswr is still ± 3 db—Fig. 2

of the line.

Delay Line—The delay-line shown in Fig. 1 has a delay range of 0 to 50 nanoseconds, an impedance of 100 ohms, and a frequency response that is flat to 50 megacycles (Fig. 2). Full delay excursion is achieved in 60 turns of the control shaft. Delay lines with delays up to 100 nanoseconds have been produced in

THE ROLLER DELAY LINE in effect simulates a varying length of coaxial cable and can be spliced directly into a circuit without impedance mismatch. Its anti-backlash features provide accurate resetability and exceptional shaft angle to delay linearity.

Standard Roller Lines are designed for hand operation and should not be motor driven at speeds of over 150 RPM. Ruggedized versions for higher speed operations are provided on special order.

The listing of standard models on the back of this sheet is only indicative of the characteristics that can be provided. All models shown are provided in any case or terminal configuration on request.

Longer delays and different impedances are provided in larger case sizes on special order.

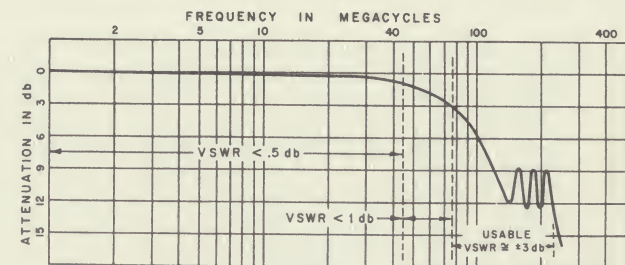
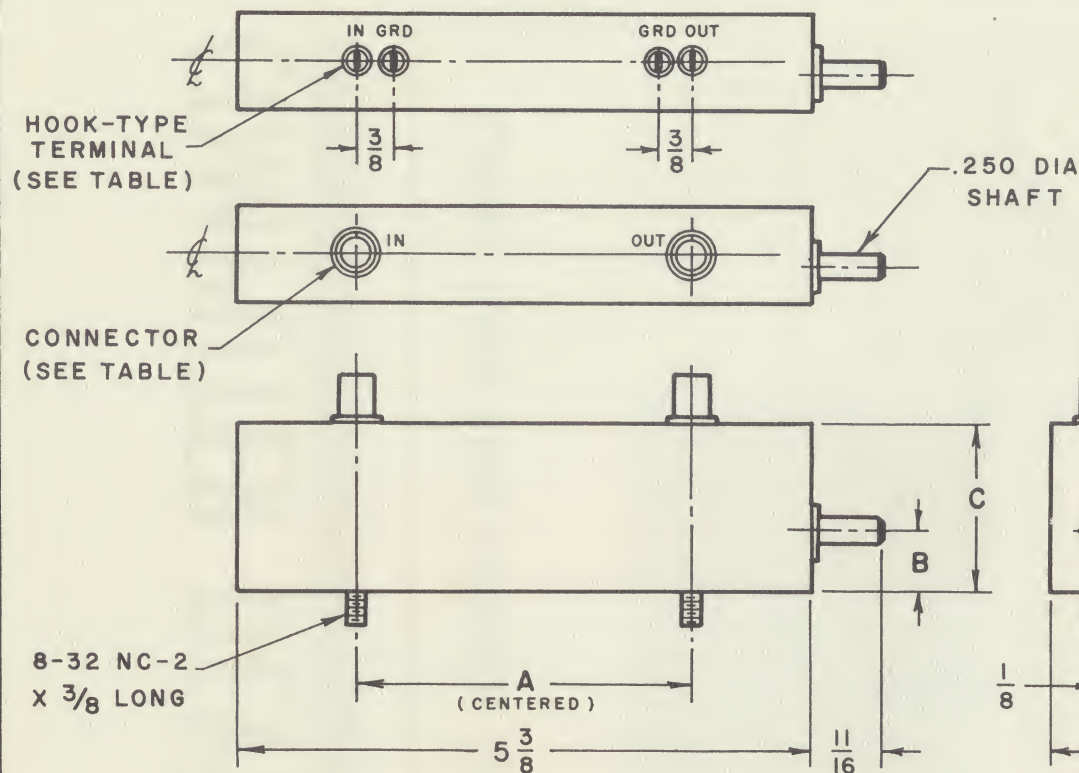


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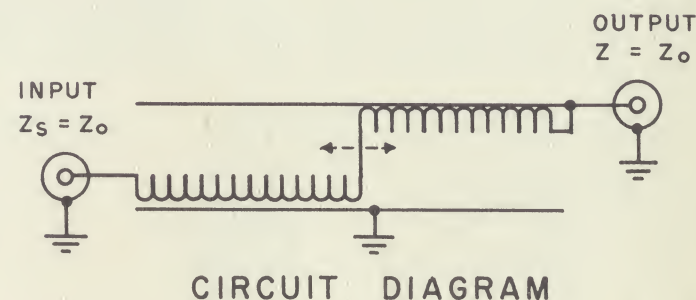
6 W. 18TH STREET, HUNTINGTON STA., L.I., N.Y.

TEL: 516 - AR1-0666, TWX: 516 - 421-4235



TYPICAL AMPLITUDE vs FREQUENCY

MODELS DV580-1 AND DV520-1 HAVE SLOTTED .250 DIA SHAFTS WITH 3/8-32 THREADED BUSHING. SHAFT LOCK CAN BE PROVIDED.



NOTE: ALL MODELS, HERMETICALLY SEALED METAL CASES WITH GRAY LACQUER FINISH.

TABLE OF ELECTRICAL SPECIFICATIONS (AND CORRESPONDING DIMENSIONS)						
MODEL	DV575	DV580	DV581	DV576	DV580-1	DV520
DELAY RANGE NANOSECONDS	2 TO 25	2 TO 50	2 TO 50	2 TO 50	2 TO 25	2 TO 50
FREQ. RESPONSE MC MINIMUM	70	70	70	70	70	70
INSERTION LOSS DB	1	1	1	1	1	1
IMPEDANCE INPUT & OUTPUT (OHMS)	200	100	200	93	50	93
DELAY PER TURN NANOSECONDS	0.42	0.84	0.55	0.84	0.84	0.84
CONNECTOR	TERM.	BNC	TERM.	BNC	TSM	TSM
DIMENSION A	3.37	3.37	3.37	3.37	3.25	3.25
DIMENSION B	1 1/16	1 1/16	1 1/16	1 1/16	5/8	3/8
DIMENSION C	1 3/4	1 3/4	1 3/4	1 3/4	1 1/4	1 1/4

DELAY LINE,
VARIABLE
—
CONSTANT IMPEDANCE
INFINITE RESOLUTION

COMPUTER DEVICES
CORP.

6 WEST 18 TH ST.
HUNTINGTON STA., N.Y.

SCALE 1/2 = 1

DWN Rnk 9/25/63

APPVD E.W.

CHKD K. Dunne

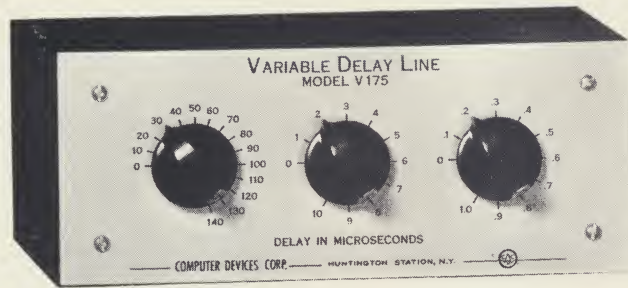
A 57502

SIZE DWG NO.

REV.



DELAY LINES FOR AUDIO FREQUENCIES



This series of lumped constant Delay Lines is specifically designed for use in the AUDIO and low frequency range (0 to 60 kilocycles). Special "M" section designs, high "Q" coils and temperature compensating capacitors are used to provide minimum phase distortion, low VSWR, low insertion loss and good temperature stability. They are particularly applicable to such sonic, sub-sonic and ultra-sonic uses as:

- ANALOG COMPUTERS
- AUTO CORRELATION
- SONAR
- SEISMIC WORK
- SONAR RANGING
- TELEPHONE LINE CORRECTION

Type	Model	Delay in μ s	Fco in Kcs	Z in Ohms	Insertion Loss db	Tap Delay or Step Delay	Size in inches
FIXED AND TAPPED DELAY	DA131	74.4	43	1200	.5	4.65 μ s	4 x 2-1/4 x 1-1/4
	DA158	208	50	680	.7	4	5 x 4-1/2 x 1-1/4
	DA301	1000	40	600	3	20	19 x 3-1/2 x 9
	DA261	5000	10	500	3	40	19 x 5-1/4 x 10
	DA177	100000	0.4	1000	10	1000	19 x 21 x 12
VARIABLE DELAY	AV175	0 to 150	60	500	6	.1	9 x 3 x 6
	AV206	0 to 1000	40	600	3	1.0	19 x 3-1/2 x 12
	AV211	0 to 10000	5	600	3	.1	19 x 5-1/4 x 15
	AV287	0 to 500	40	1000	3	.002	19 x 3-1/2 x 12
BALANCED DELAY LINES	DBA149	1000	7	600	1	50	19 x 1-3/4 x 5
	DBA173	2000	7	600	2	50	19 x 3-1/2 x 5
	DBA315	4000	7	600	4	50	19 x 7 x 5
	DBA320	8000	7	600	8	50	19 x 7 x 9

- VSWR - Less than $\pm 1/2$ db up to 50% of cut-off frequency
- PHASE LINEARITY - Less than $\pm 1/4\%$ up to 50% of cut-off frequency
- TEMPERATURE STABILITY - Less than 40 PPM/ $^{\circ}$ C from -55° C to $+85^{\circ}$ C

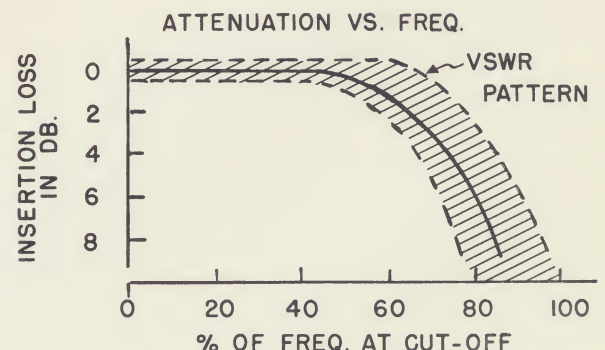
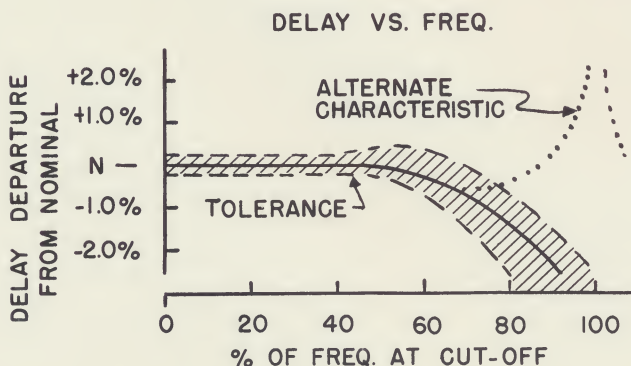
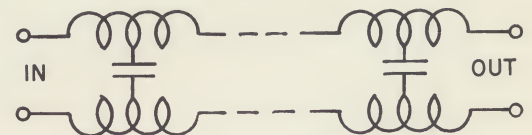
AUDIO DELAY LINES are generally custom made to meet a specific requirement. The above listing is indicative of the attainable characteristics. Variations of delay time, voltage standing wave ratio, frequency response, tap spacing, impedance, etc. are tailored to meet customers' specifications.

TAPPED DELAY LINES are manufactured with as many tap delay points as desired. The above listing suggests tap spacing that is economically available and a practical limit on tap spacing is about 1/10 of that shown.

DELAY ACCURACY: Standard accuracy on total delay and tap delay is 1% of delay and accuracies better than .1% are available.

VARIABLE DELAYS are supplied as a multi-control decade switch arrangement. The decades use the insertion principle and are ganged to provide any resolution required. Where very fine resolution is required, the fine control is accomplished with a continuously variable Delay Line, thus providing very high resolution of a very long delay. (See AV287 above.)

BALANCED DELAY LINES are designed specifically for time compensation of balanced ungrounded 600 ohm systems. They are particularly useful in telephone and voice transmission applications. The basic balanced Delay Line circuit is:



COMPUTER DEVICES CORP.

TEL: AR 1-0666



6 WEST 18 STREET HUNTINGTON STATION, N.Y.

All CDC Delay Lines are manufactured to meet the rugged Mil specs for ship - land - aircraft and missile equipment.